

Status of the ATLAS experiment and early physics measurements

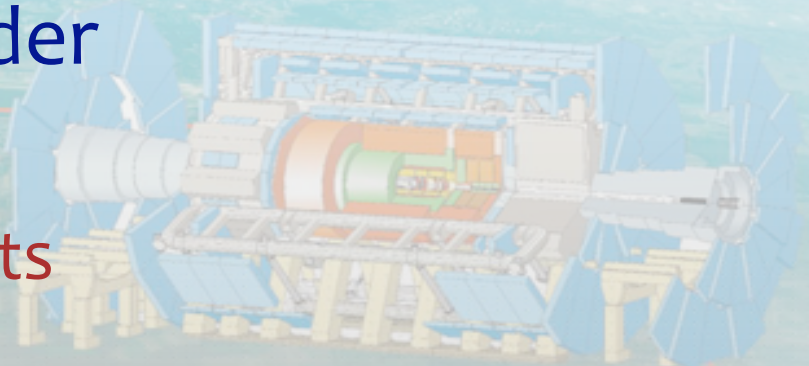
M. Iodice

INFN Roma Tre

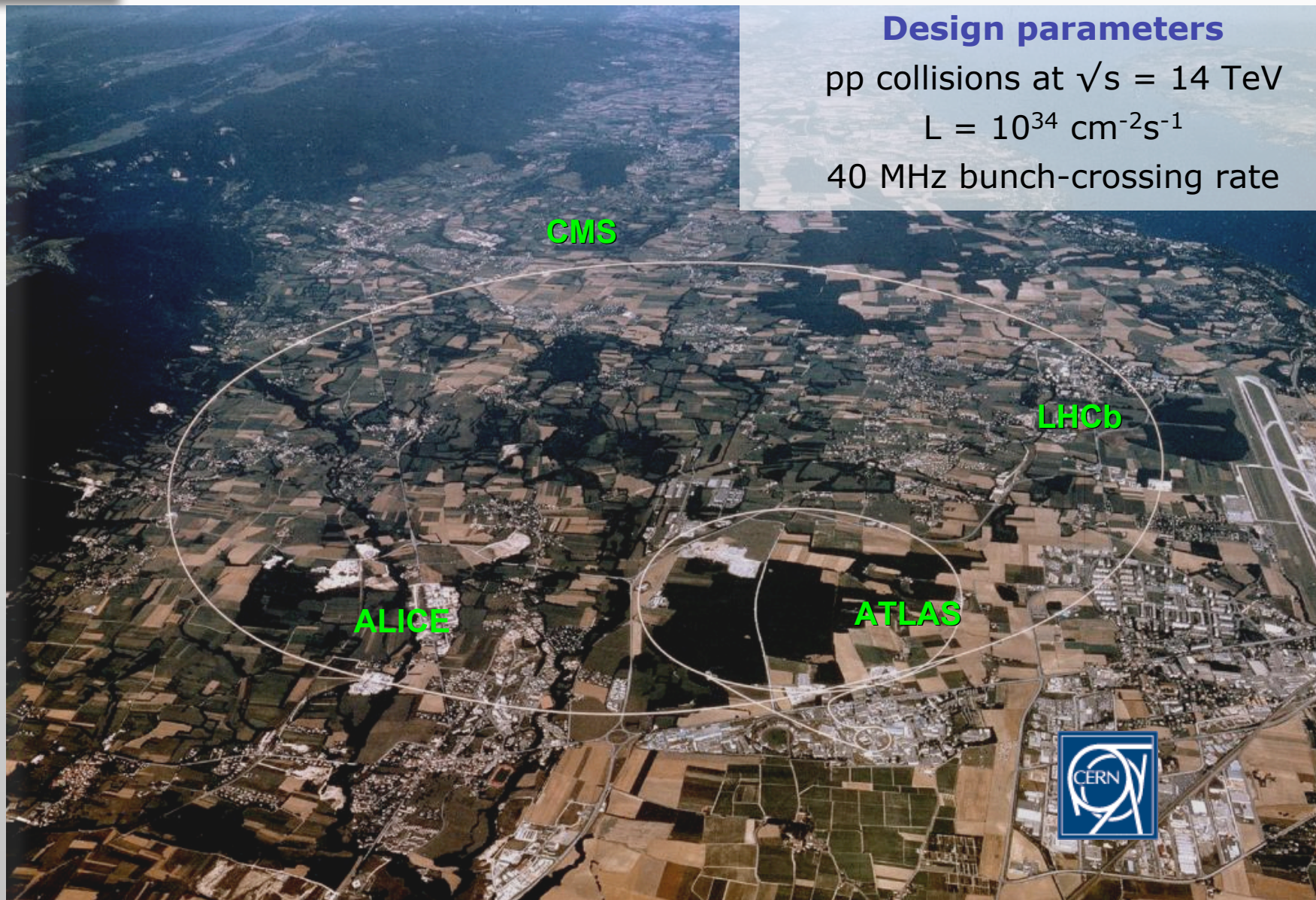
on behalf of the ATLAS Collaboration



- The Large Hadron Collider
- the ATLAS experiment
 - design and requirements
 - detector components
 - Commissioning of the detectors and results with cosmics data
- Early physics measurements



The Large Hadron Collider at CERN



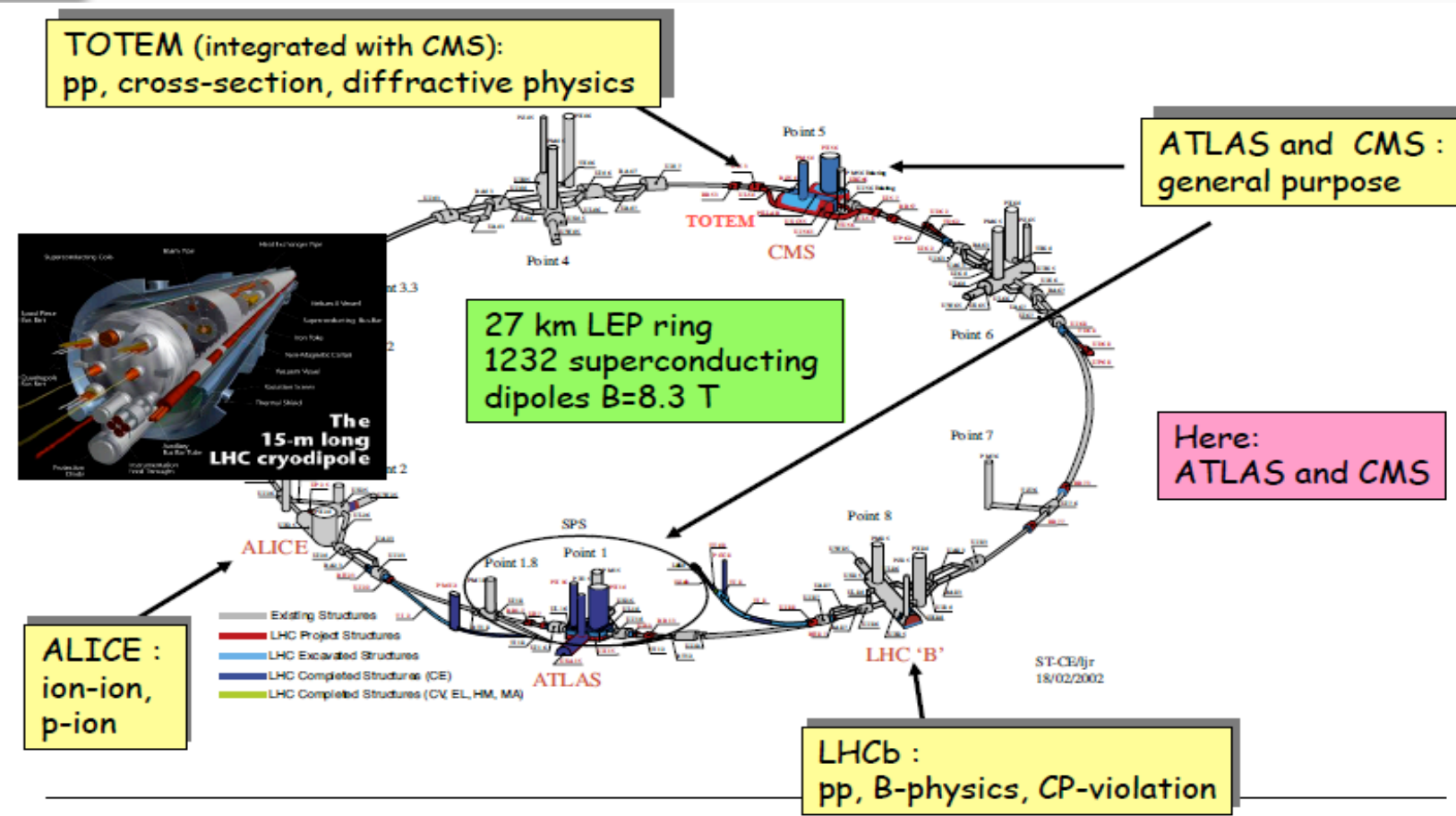
Design parameters

pp collisions at $\sqrt{s} = 14 \text{ TeV}$

$L = 10^{34} \text{ cm}^{-2}\text{s}^{-1}$

40 MHz bunch-crossing rate

The Large Hadron Collider at CERN



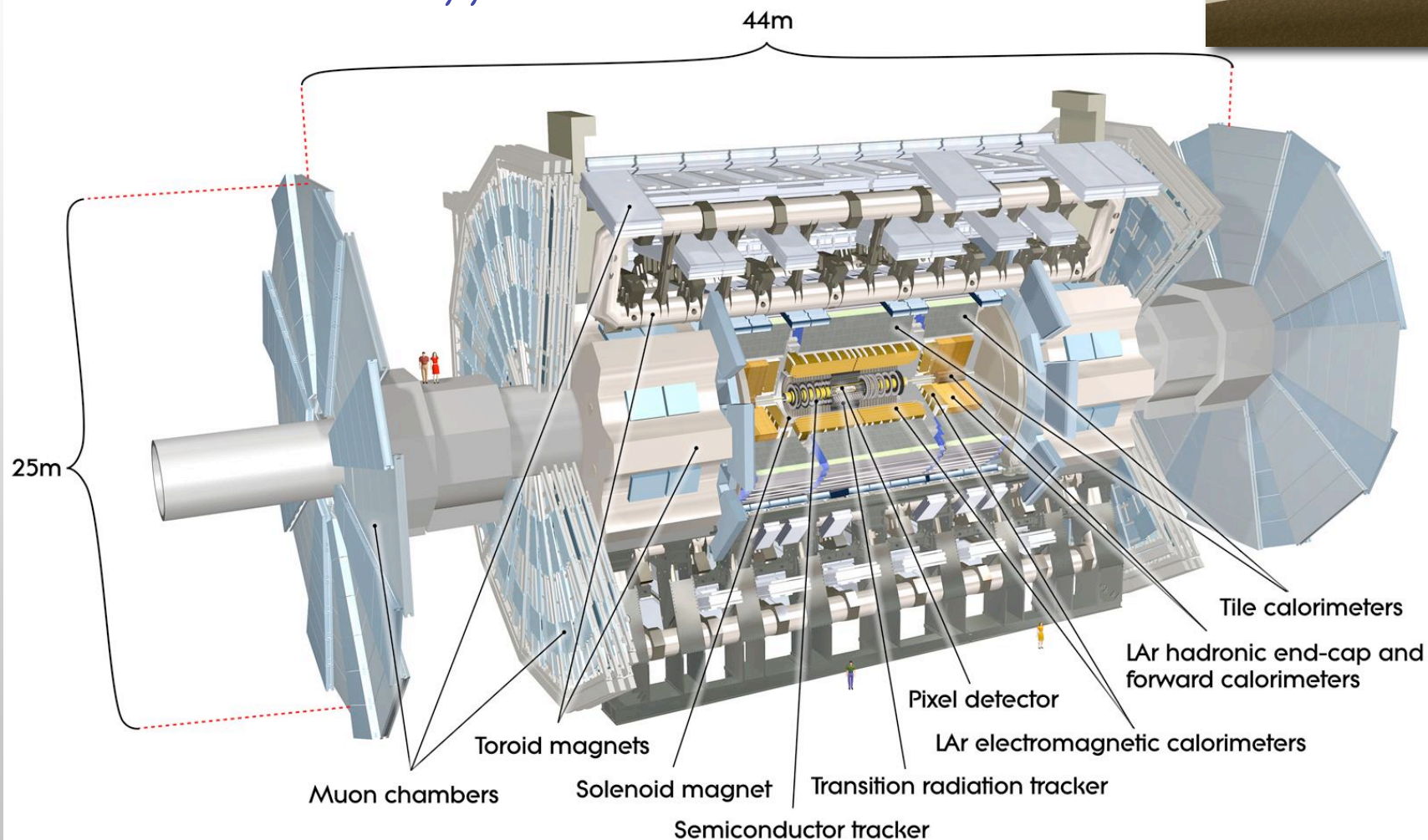
STARTUP SCENARIO

- LHC will be closed up and ready for **beam injection by mid-November 2009**
- Start collisions at **4-5 TeV** per beam in 2009 aiming at a long run in 2010
- Goal: **integrate in 2009/2010 $\sim 200 \text{ pb}^{-1}$**

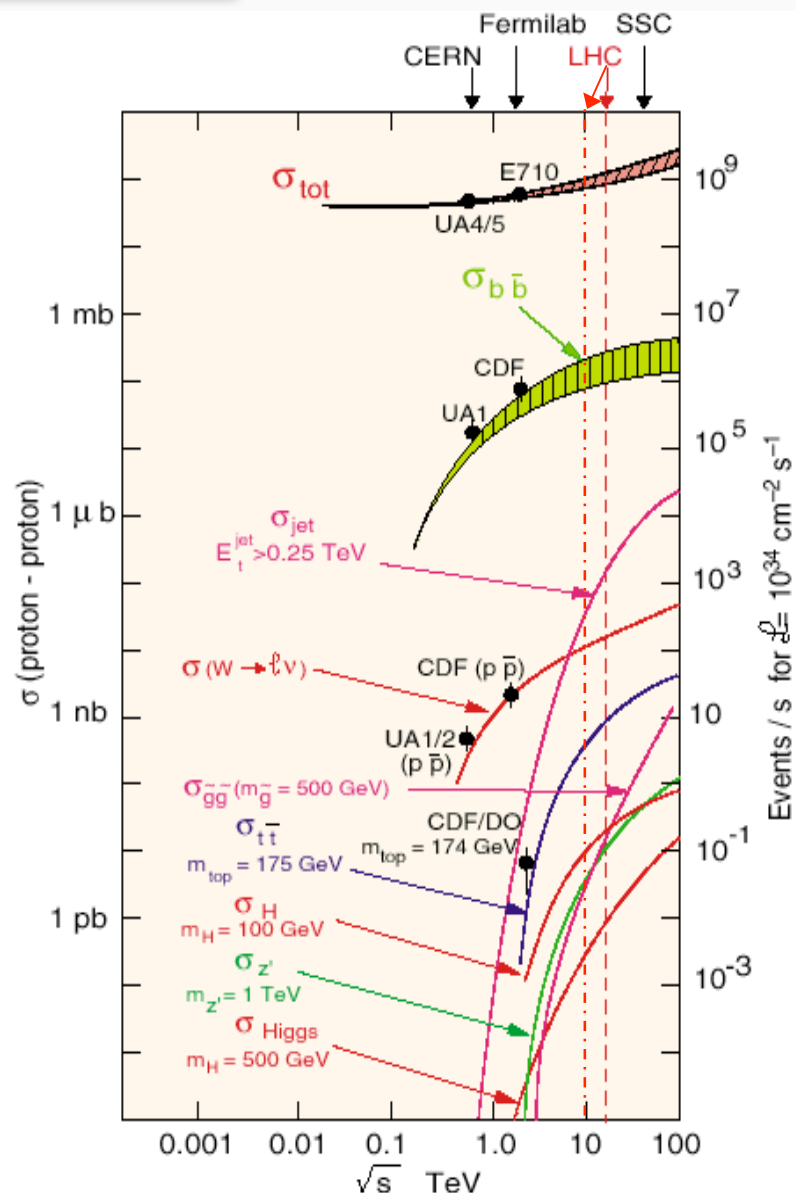
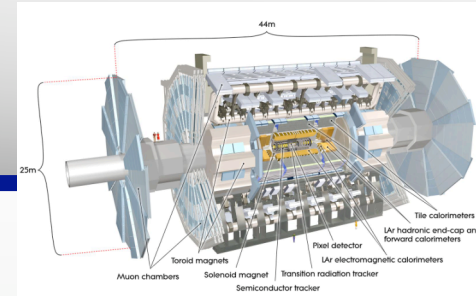
The **ATLAS** Detector



A Toroidal LHC Apparatus



The ATLAS design

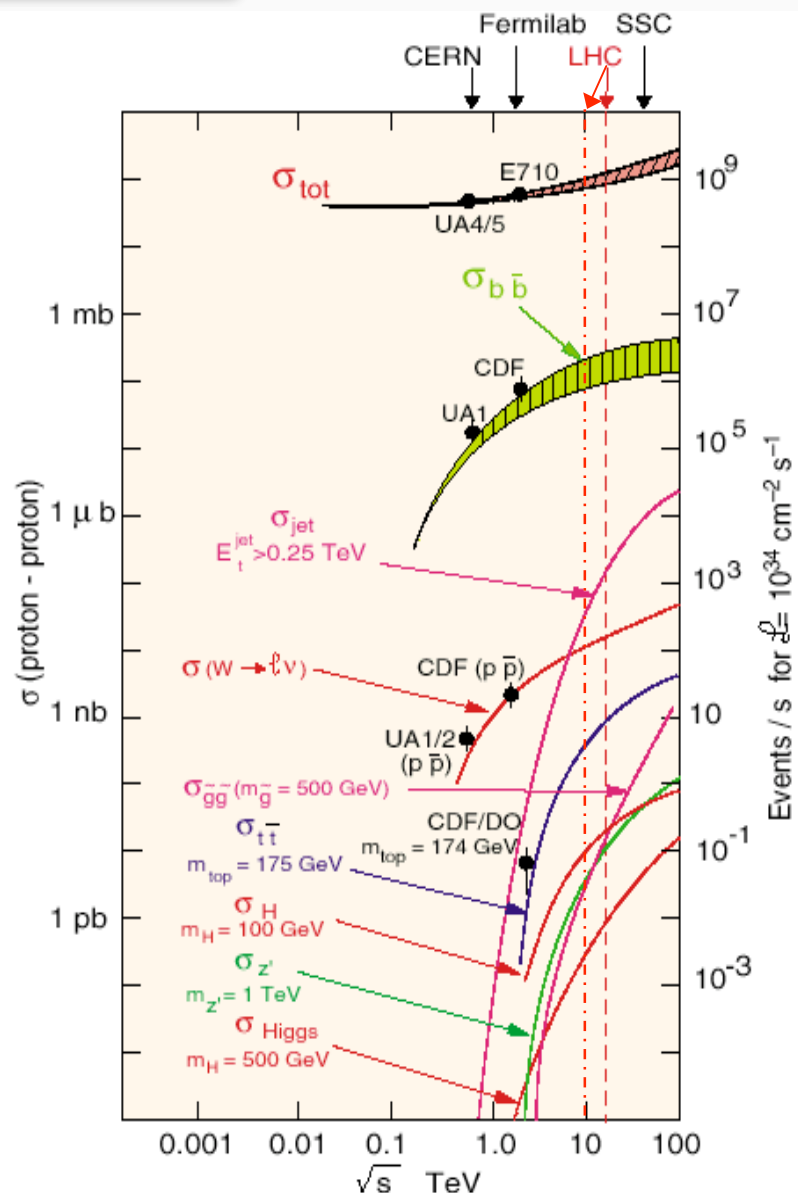
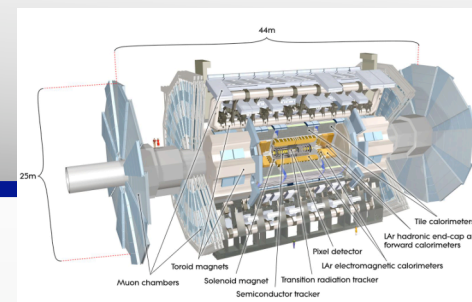


- LHC is essentially a *gluon-gluon* collider
⇒ QCD production dominant
- Around $p_T = 20$ GeV, $jet/e(\mu) \approx 10^5$
⇒ need larger order of jet rejection power

Orders of magnitude of event rates for various physics channels at design luminosity:

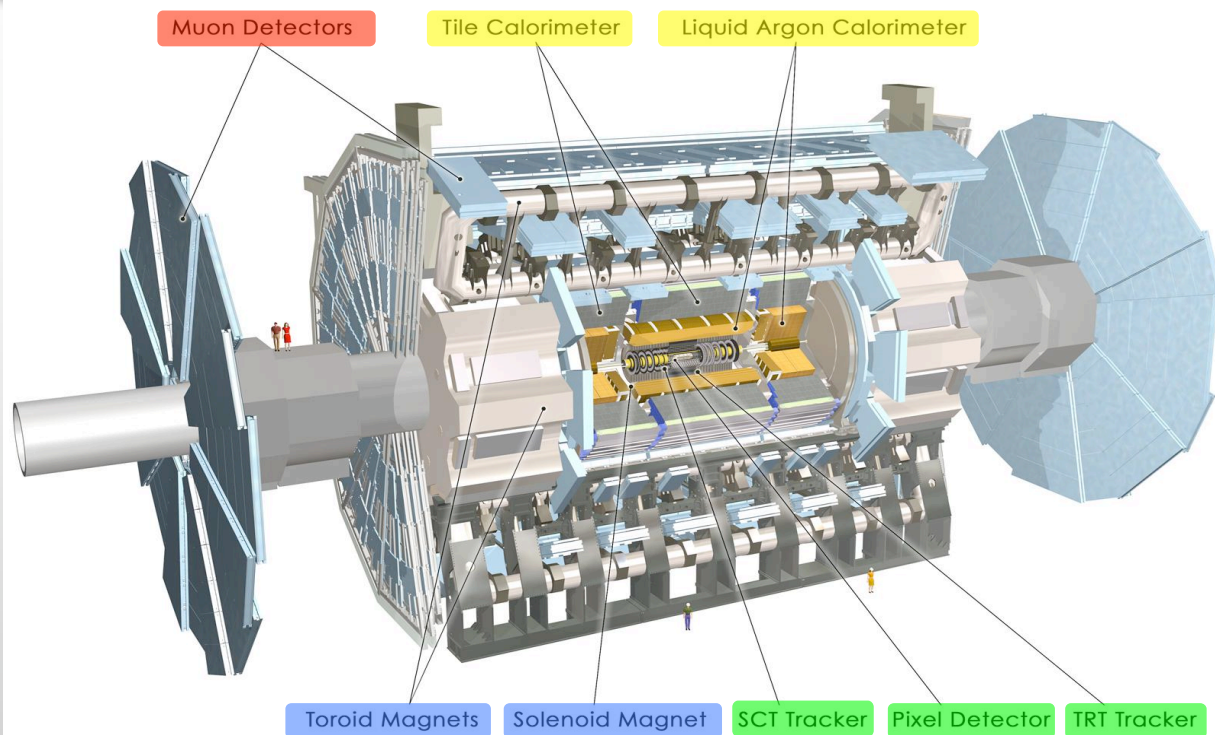
- Inelastic: 10^9 Hz
- $W \rightarrow l \nu$: 10^2 Hz
- tt production: 10 Hz
- Higgs ($m=100$ GeV): 10^{-1} Hz
- Higgs ($m=600$ GeV): 10^{-2} Hz

The ATLAS design



- High resolution and high acceptance MUON measurements, using an Air-Core Toroid (reduce multiple scattering), with rapidity coverage up to 2.7 (STANDALONE Muon Spectrometer)
- Very good electromagnetic calorimetry for electron and photon identification (e/γ) complemented with a Transition Radiation Tracker
- High hermeticity, with calorimetric coverage down to rapidity of 5 for high resolution measurements of missing E_T and $E(\text{jet})$.
- Good tracking for leptons and vertex resolution (with 3 layers of pixel)

The **ATLAS** detector components



The Magnet system:
Four Superconducting magnets:

1 Central Solenoid
3 Air core Toroids

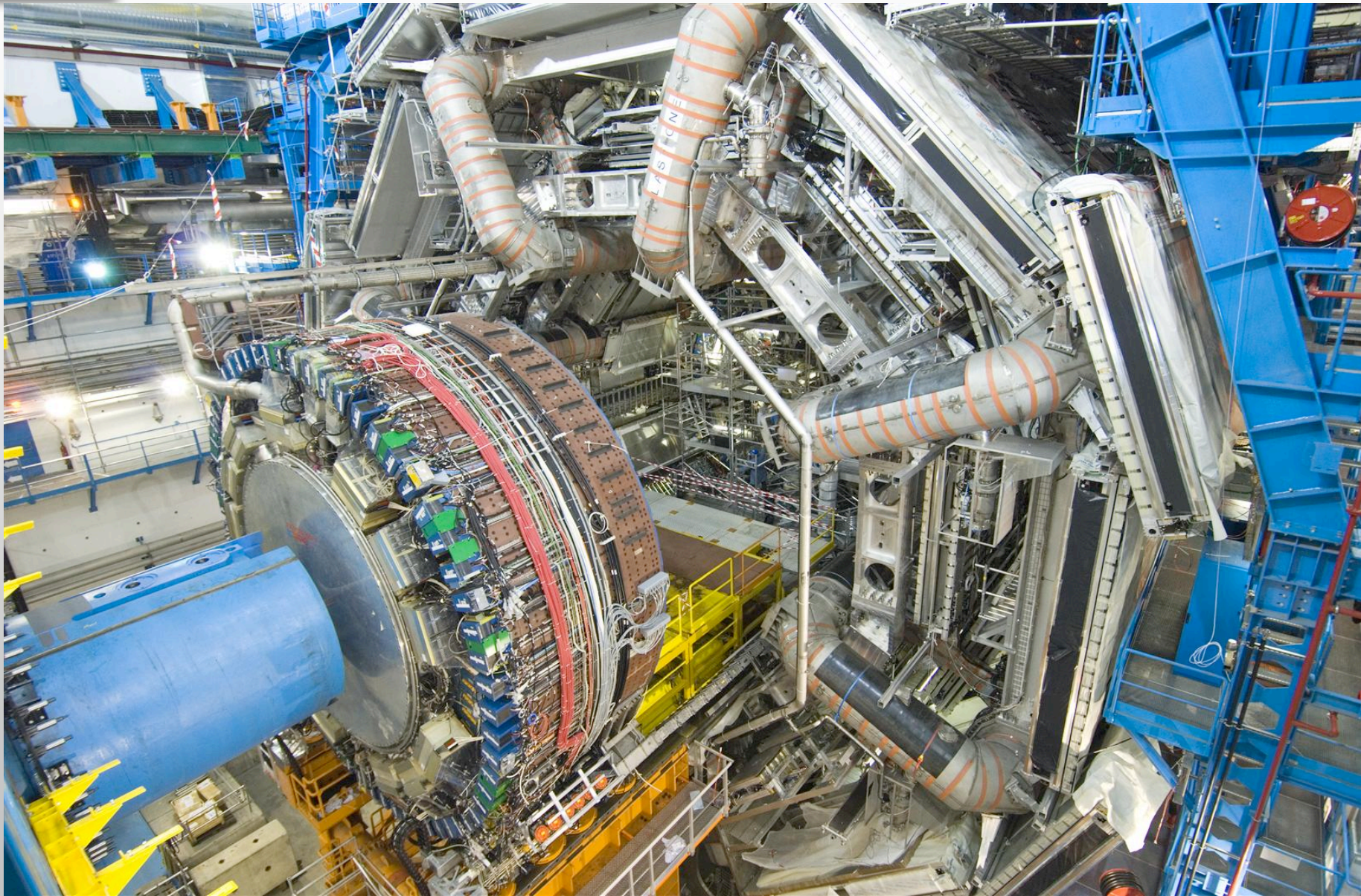
The Inner Detector

EM and hadronic
Calorimeters

The Muon Spectrometer

Subdetector	Required resolution	η coverage	
		Measurement	Trigger
Tracking	$\sigma_{p_T}/p_T = 0.05\% p_T \oplus 1\%$	± 2.5	
EM calorimetry	$\sigma_E/E = 10\%/\sqrt{E} \oplus 0.7\%$	± 3.2	± 2.5
Hadronic calorimetry (jets)			
Barrel and Endcap	$\sigma_E/E = 50\%/\sqrt{E} \oplus 3\%$	± 3.2	± 3.2
Forward	$\sigma_E/E = 100\%/\sqrt{E} \oplus 10\%$	3.1 – 4.9	3.1 – 4.9
Muon spectrometer	$\sigma_{p_T}/p_T = 10\%$ at $p_T = 1$ TeV	± 2.7	± 2.4

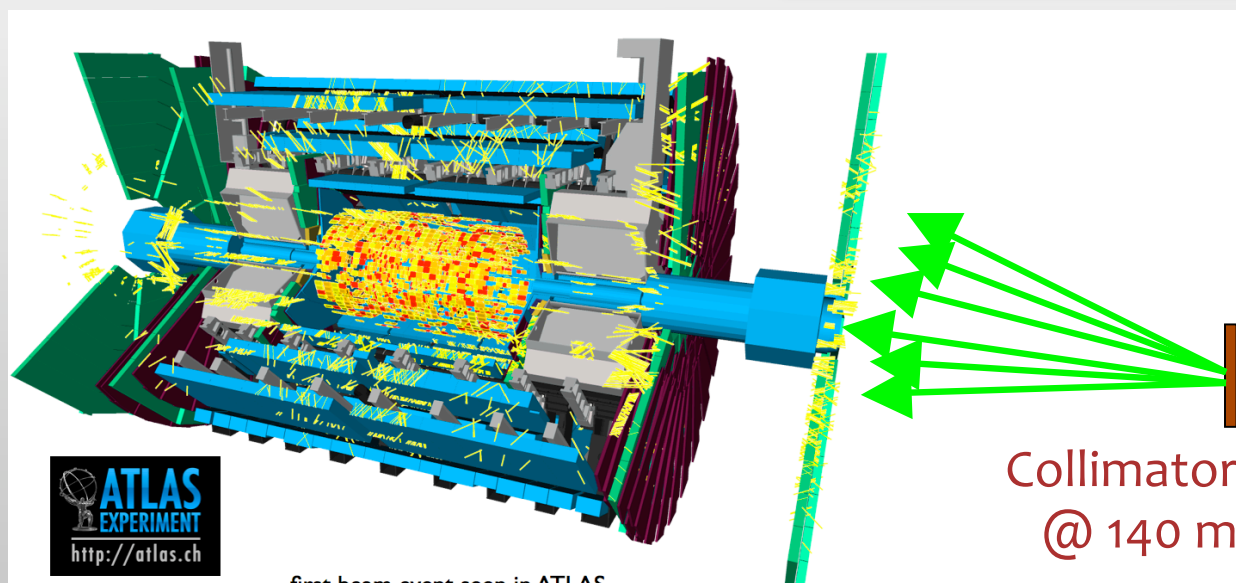
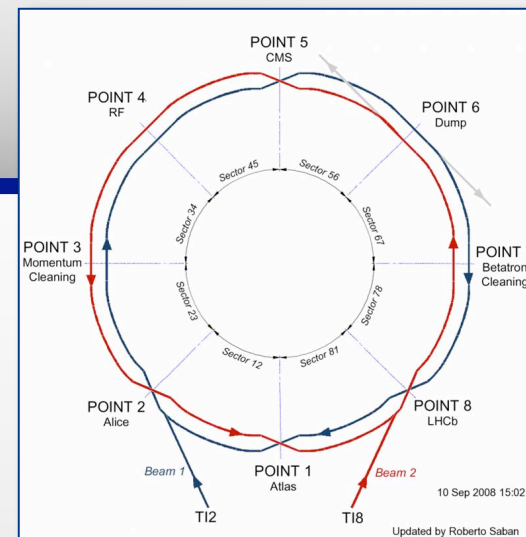
From design to reality!



Commissioning of the detector

- The commissioning of the detector started in 2006, with consecutive Milestone and Technical Runs
 - Operate together the various sub-systems testing global tools and infrastructure (DCS, DAQ, monitoring)
 - DAQ performance and trigger systems
 - Data transfer and processing (computing model and trigger selections)
 - Results and integration of calibration tools and of track-based alignment

- After almost 20 years of hard work on R&D, construction and commissioning of LHC, the first beam with 450 GeV energy passed through the LHC tunnel



first beam event seen in ATLAS

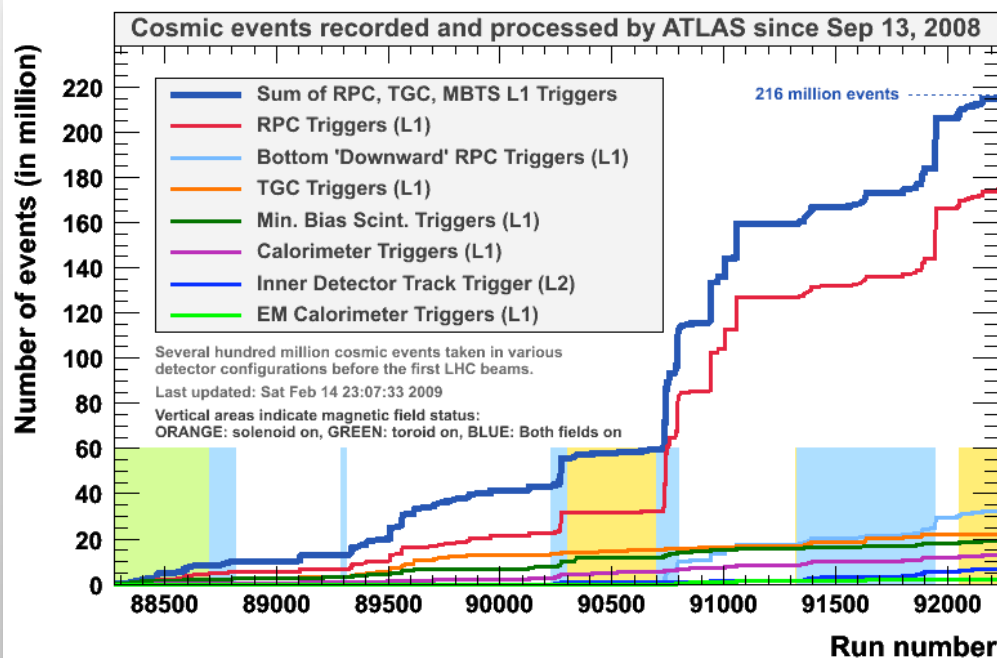
The first LHC event on 10th September 2008

A "beam splash event"

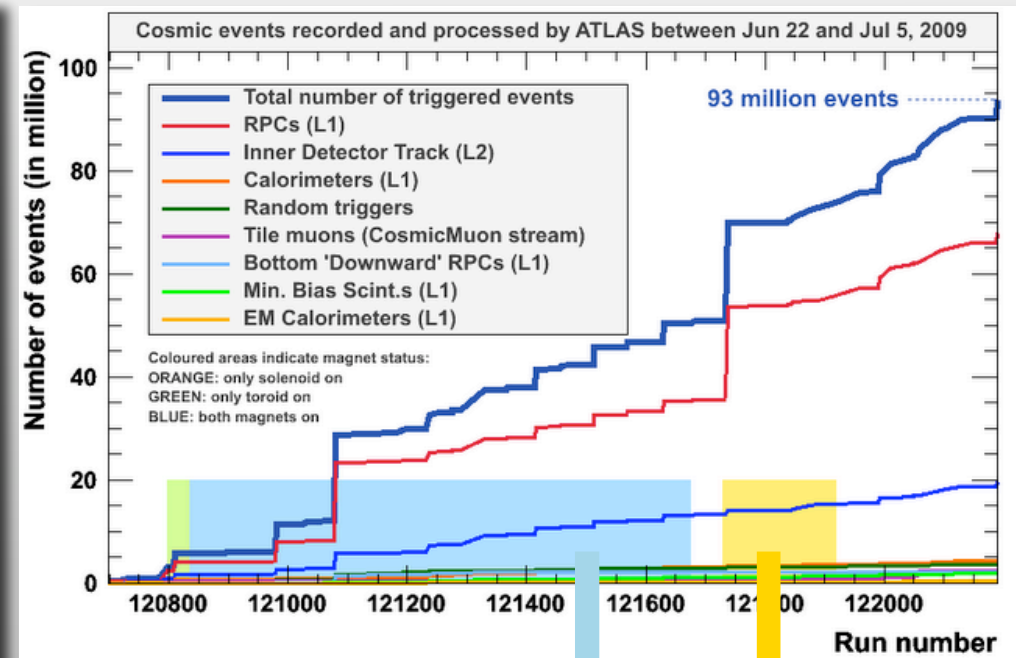
After the incident in LHC Sector 3-4 on 19th September, more than 300 M cosmoics events have been recorded so far (example of two data taking periods below)

Cosmics data becomes the primary source for detector operation and calibration

September-October 2008



June-July 2009



MAGNET (toroid and solenoid) status:
Fully tested and commissioned

LEVEL 1

- Hardware implementation Synchronous at 40 MHz (LHC clock)
- Selects Regions of Interest (ROI)
- Max Output Rate: 75 kHz
- Fixed 2.5 ms latency

LEVEL 2

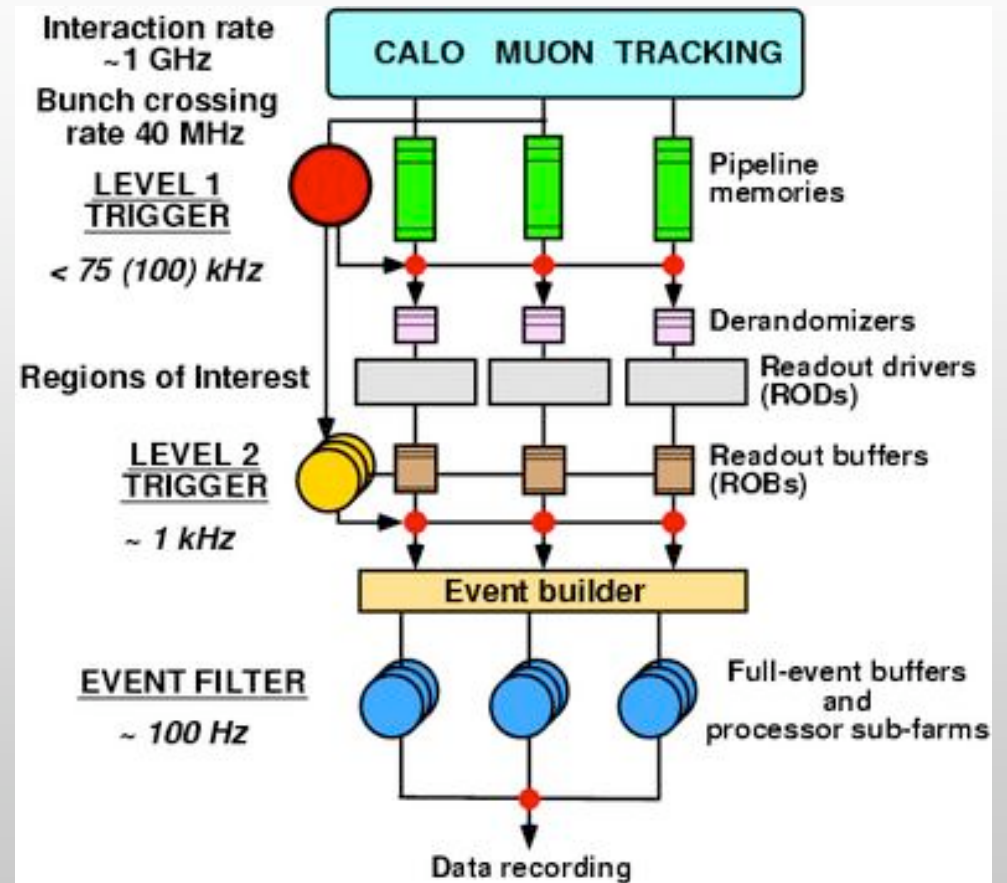
- Software implementation
- Full granularity detector information only for ROI
- Source of high statistics calibration stream
- Max Output Rate: ~ 4 kHz
- Average latency: 40 ms

EVENT FILTER

- Software implementation
- Full granularity detector information
- Max Output Rate: ~ 200 Hz
- Average latency: 4 s

High Level Trigger (HLT)

EVENT size: 1.5 - 2 MB



Three-level trigger architecture, exploiting the “region-of-interest” (RoI) approach to reduce the data-flow requirements

The Superconducting Magnets

● Central Solenoid

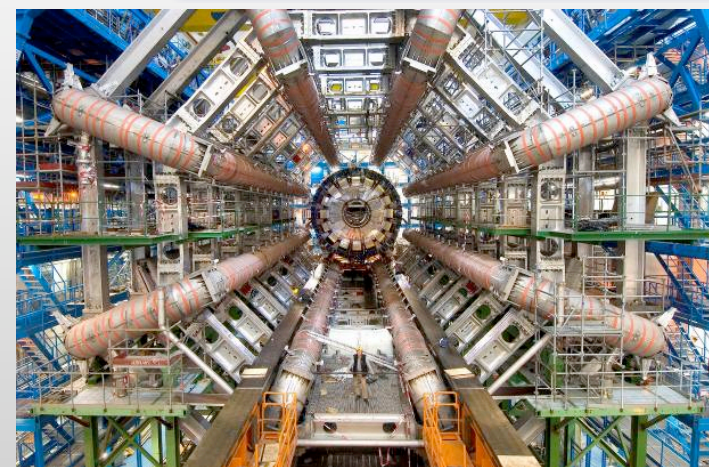
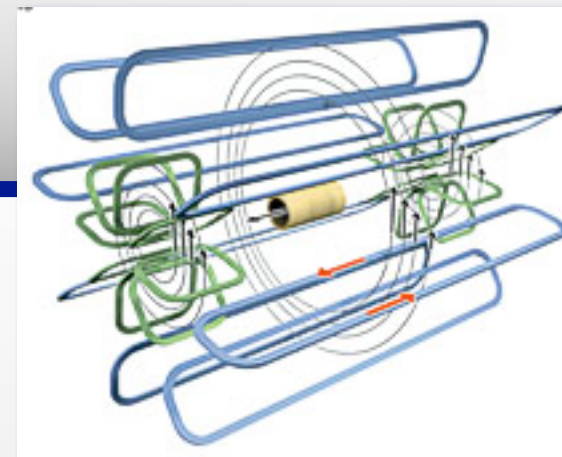
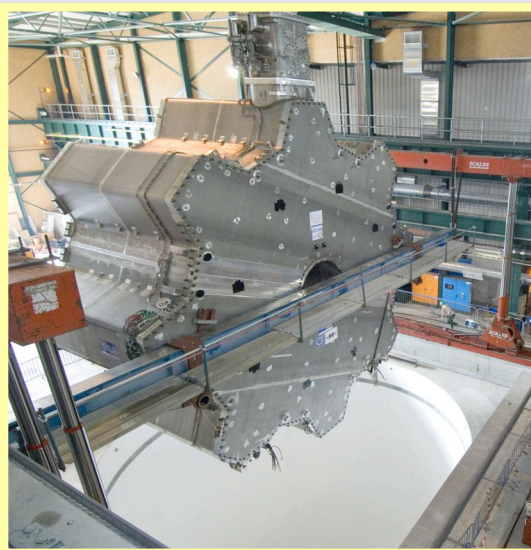
- $L = 5.3\text{m}$, $\varnothing = 2.63\text{m}$
- $B = 2\text{T}$ (@7.73 kA), $0.66 X_0$



All magnets successfully tested and operated at nominal currents for long periods (weeks)

■ Two Endcap Toroids

- 8 coils common cryostat
- $L = 5\text{m}$, $\varnothing_{\text{outer}} = 10.7\text{m}$
- $B = 0.2-3.5\text{T}$ (@20.5kA)



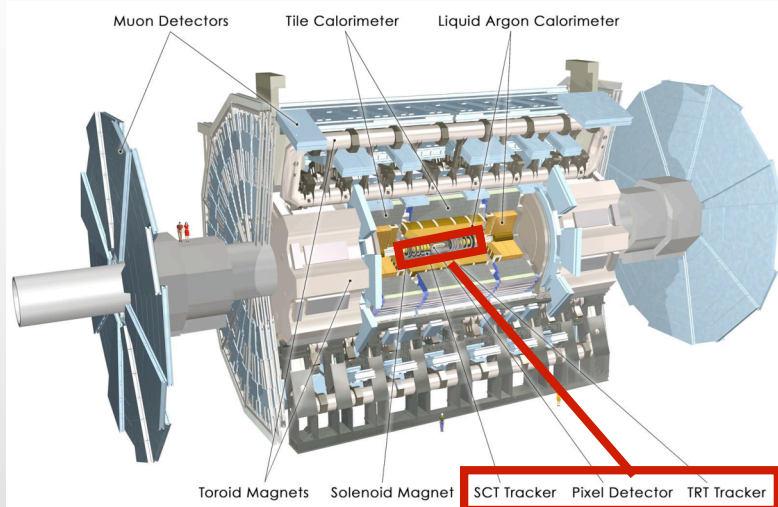
■ Barrel Toroid (8 coils)

- 8 coils
- $L = 25.3\text{m}$, $\varnothing_{\text{outer}} = 20\text{m}$
- $B = 0.2-2.5\text{T}$ (@20.5kA)

The Inner Detector



- Operates inside a 2 Tesla field
- Coverage $|\eta| < 2.5$ (TRT $|\eta| < 2.0$)



• Momentum resolution

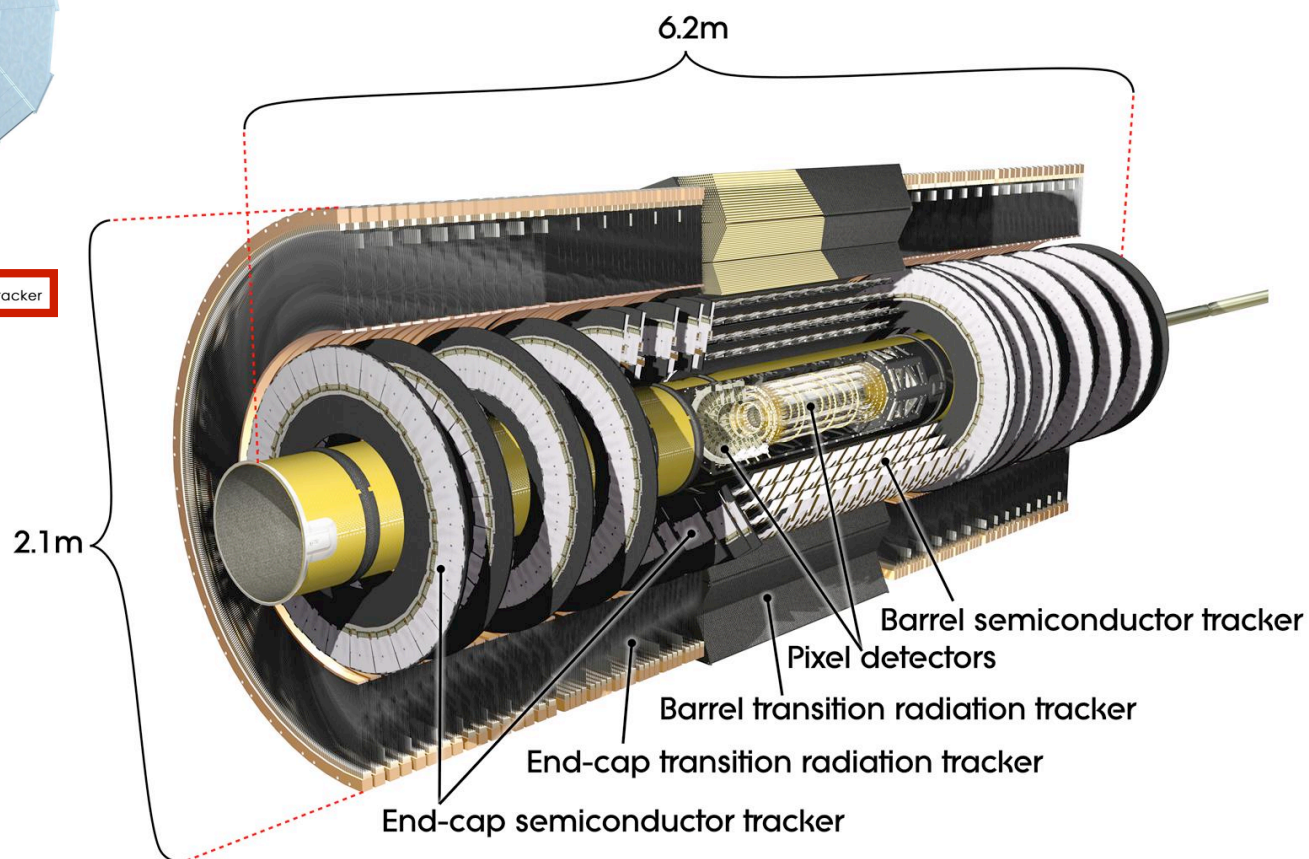
$$\sigma(p_T)/p_T = 0.05\% p_T [\text{GeV}/c] \oplus 1\% \\ (\sim 5\% \text{ at } 100 \text{ GeV})$$

• Impact parameter resolution

$$(0.25 < |\eta| < 0.5)$$

$$\sigma(d_0) =$$

$$10 \mu\text{m} \oplus 140 \mu\text{m} / p_T [\text{GeV}/c]$$



Inner Detector Components

Pixels

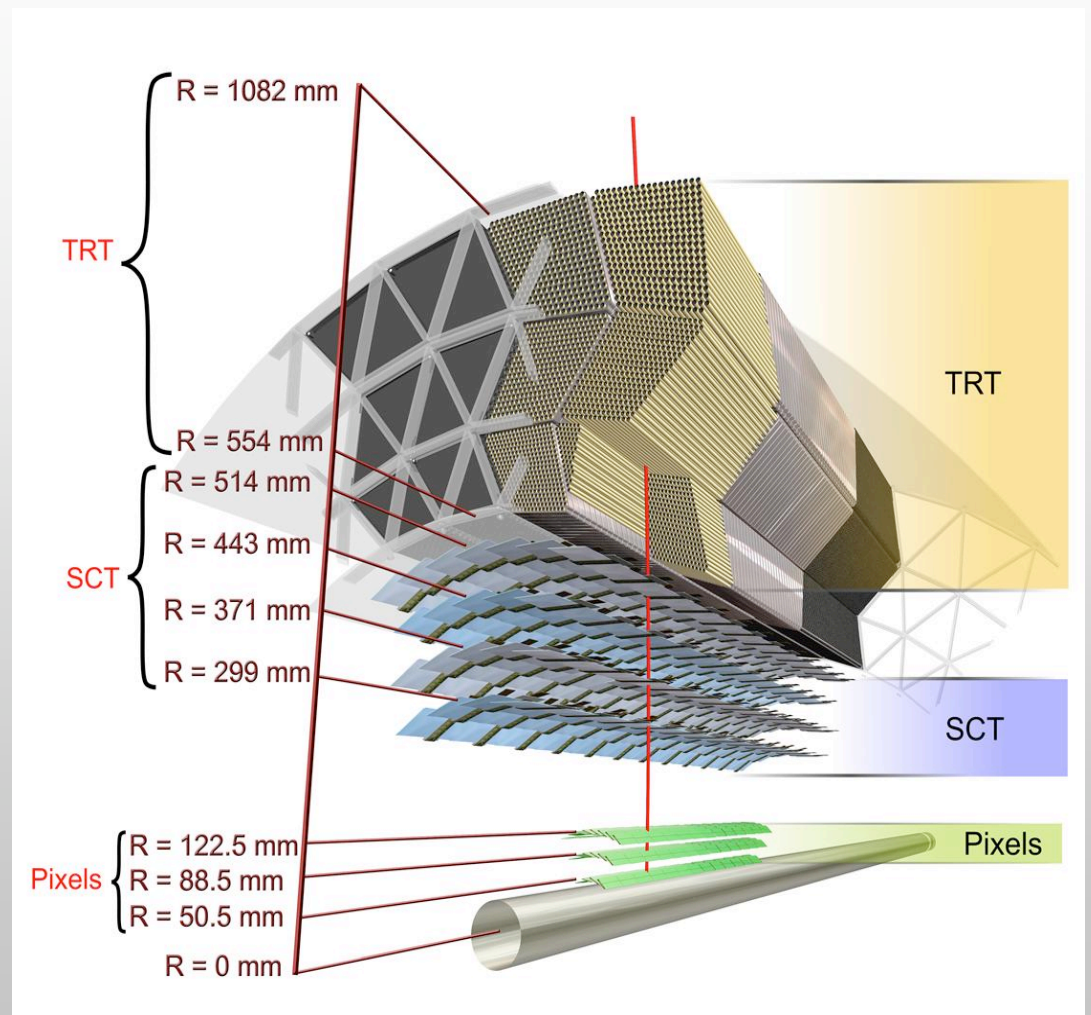
- 3 layers in barrel & endcap
- pixel size $50\ \mu\text{m} \times 400\ \mu\text{m}$
- resolution $10\ \mu\text{m} \times 110\ \mu\text{m}$
- 80 M channels

SCT (Semiconductor tracker)

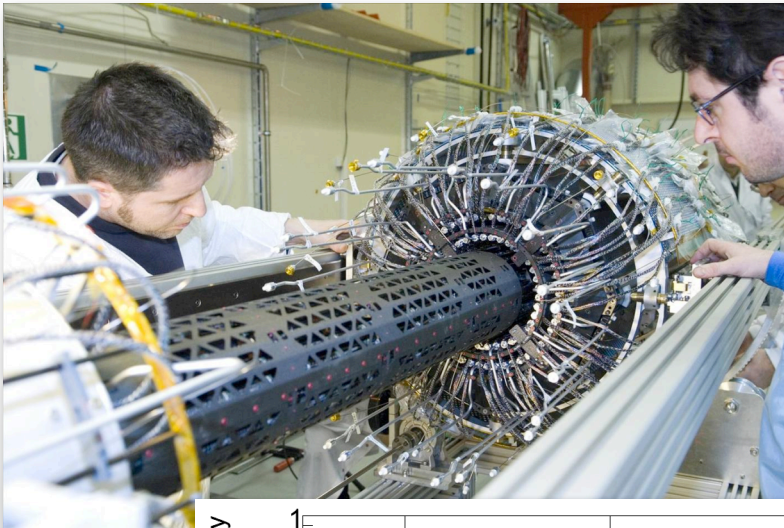
- 4 double layers of strips in barrel. 9 in endcaps.
- 4088 modules, $80\ \mu\text{m}$ strips, 6M channels.
- resolution $17\ \mu\text{m} \times 580\ \mu\text{m}$

TRT (Transition Radiation Tracker)

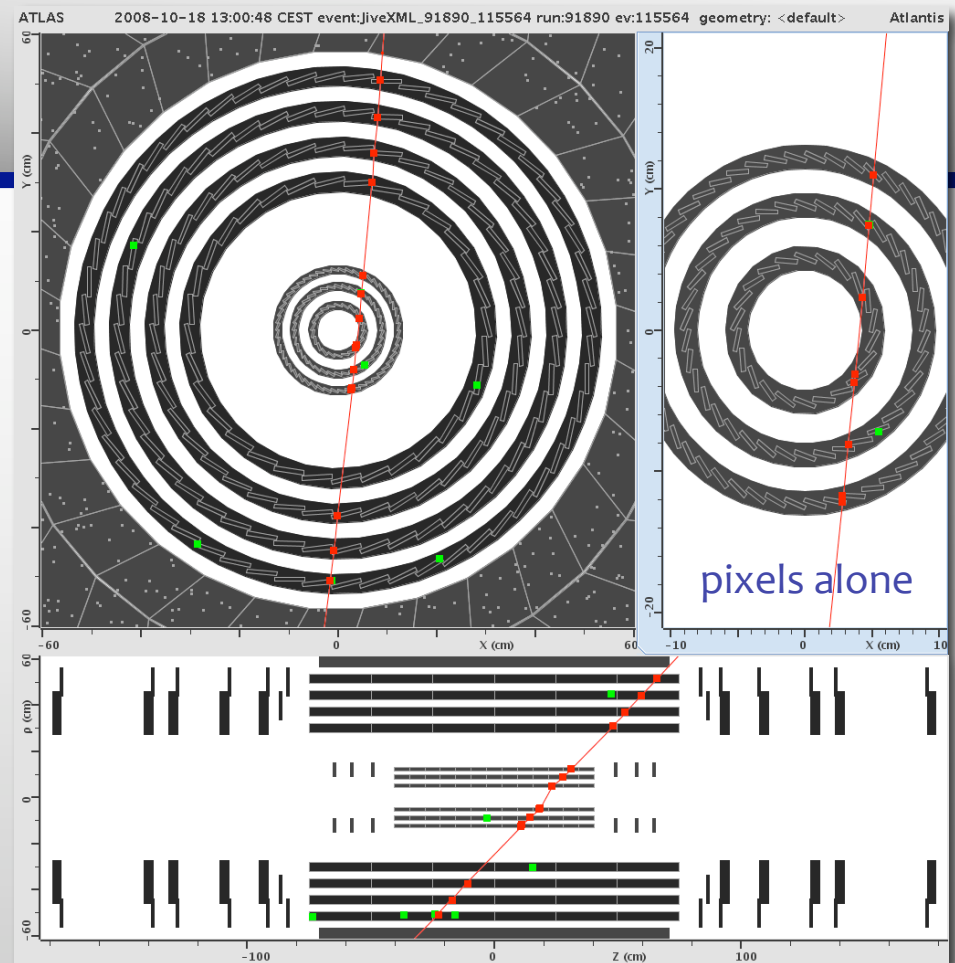
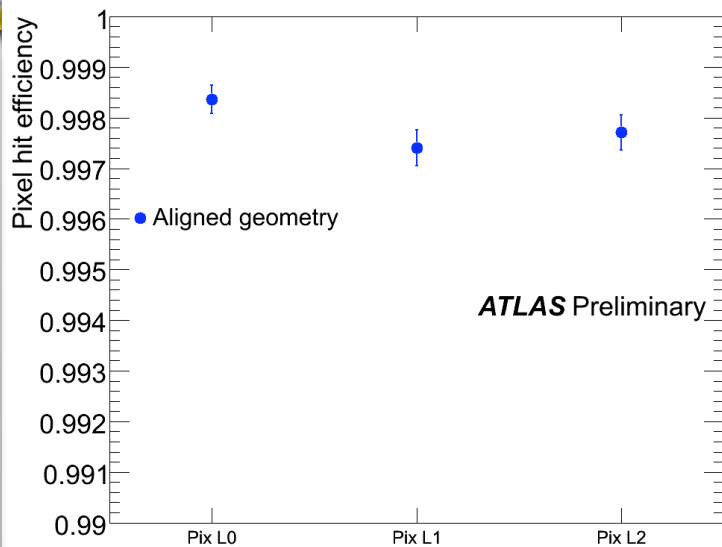
- 4mm straw tubes with $35\ \mu\text{m}$ anode wires
- Transition radiation gives $e-\pi$ separation between $0.5 < E < 150\ \text{GeV}$
- 73 barrel layers, axial straws
- 2×160 layers of radial straws in forward region, arranged in 20 discs
- resolution: $130\ \mu\text{m}$



The Pixel Detector



**about
99.8%
efficiency**
in all three
layers
using the
official
alignment
of ATLAS



Cosmic ray event display through Pixels and SCT

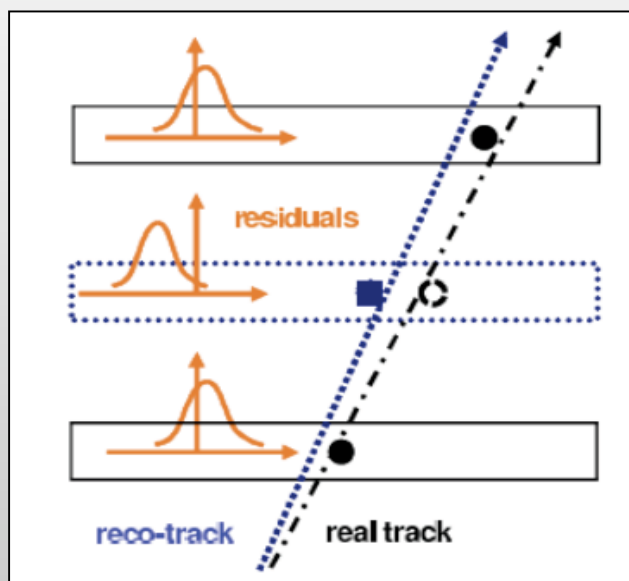
The track has a hit in each of the layers in both the upper and the lower hemisphere. Only one other hit in the pixel detector demonstrating the very low noise level

The Pixel Detector - alignment

The position (“alignment”) of the Pixels and SCT detector modules must be known to a few microns for a precise reconstruction of the track parameters.

The detector alignment is performed using tracks and an iterative procedure that minimizes the **hit residuals**.

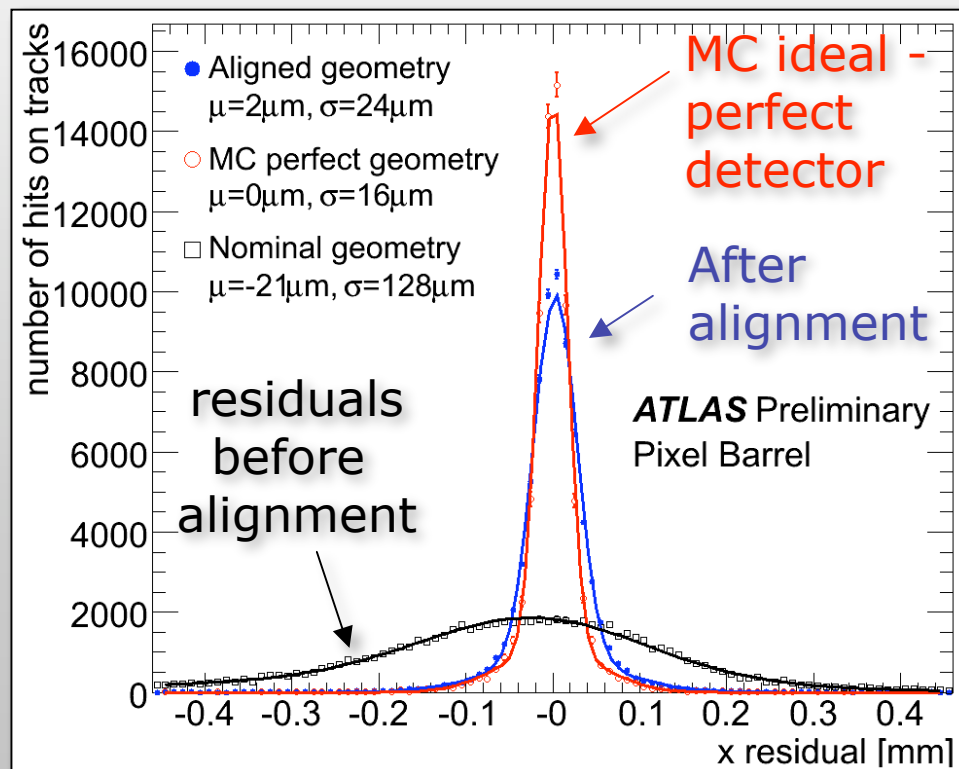
~36000 degrees of freedom: 6000 modules x (3 position coordinates + 3 rotation angles)



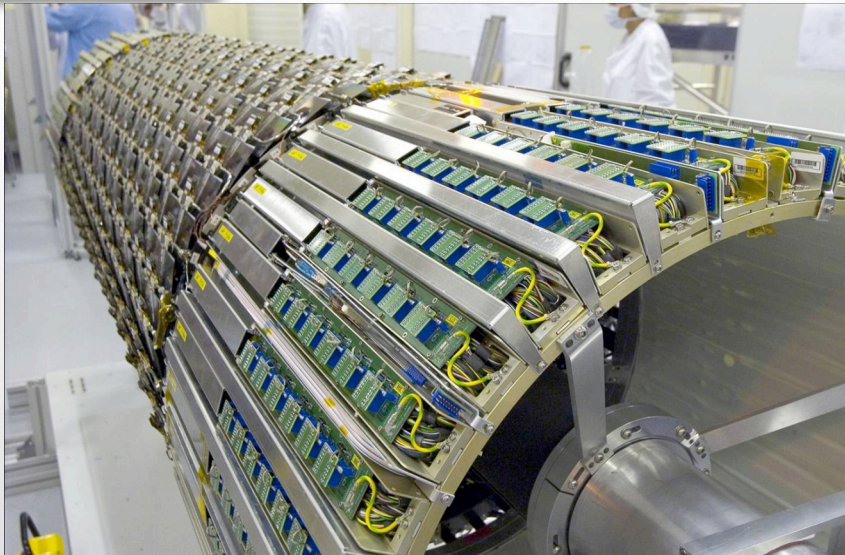
hit residuals: distance between the fitted track and the hit in the layer

Pixels
Alignment
with ID
combined
cosmics tracks

After alignment:
hit residuals peak at ~zero with $\sigma=24 \mu\text{m}$ close to pixel resolution



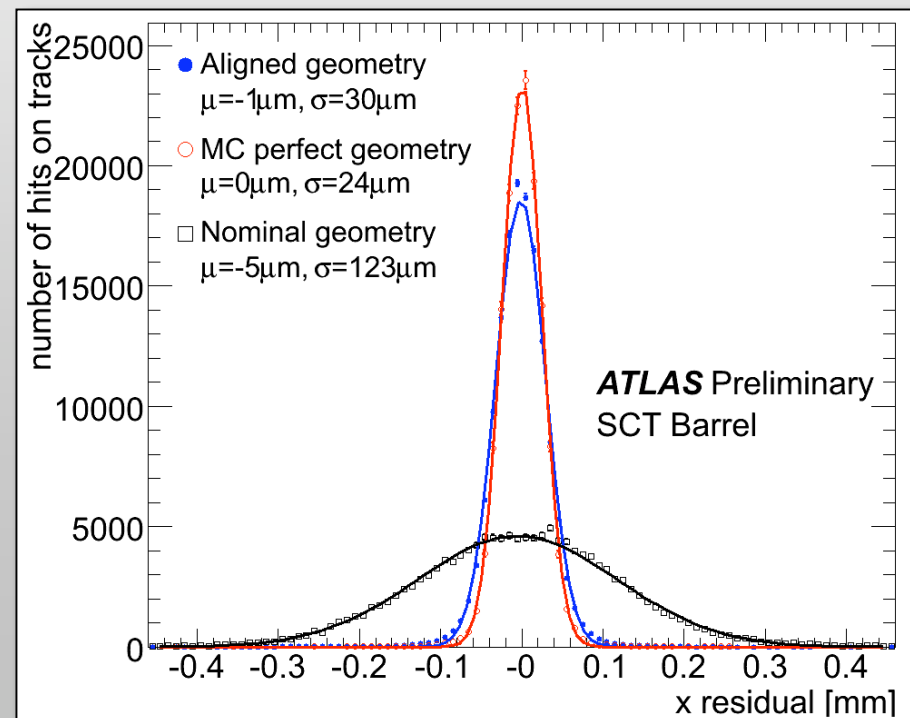
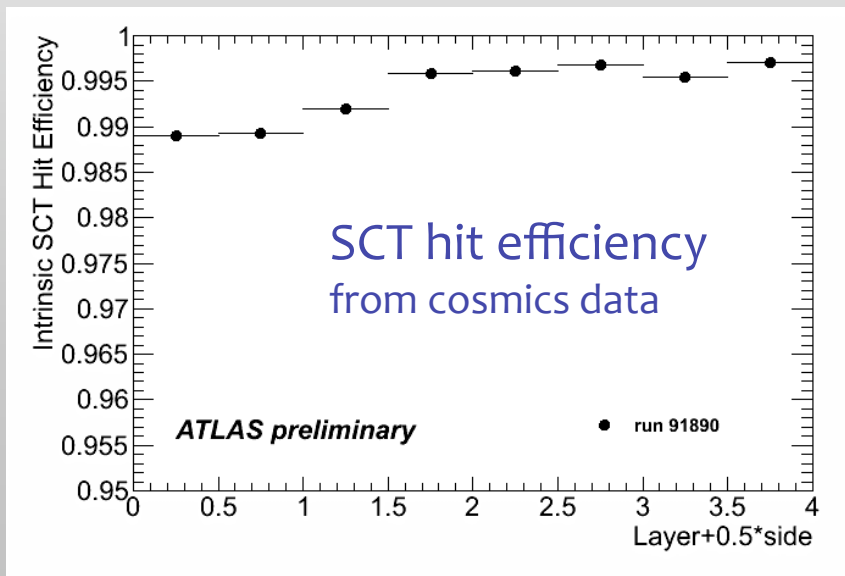
The SemiConductor Tracker (SCT)



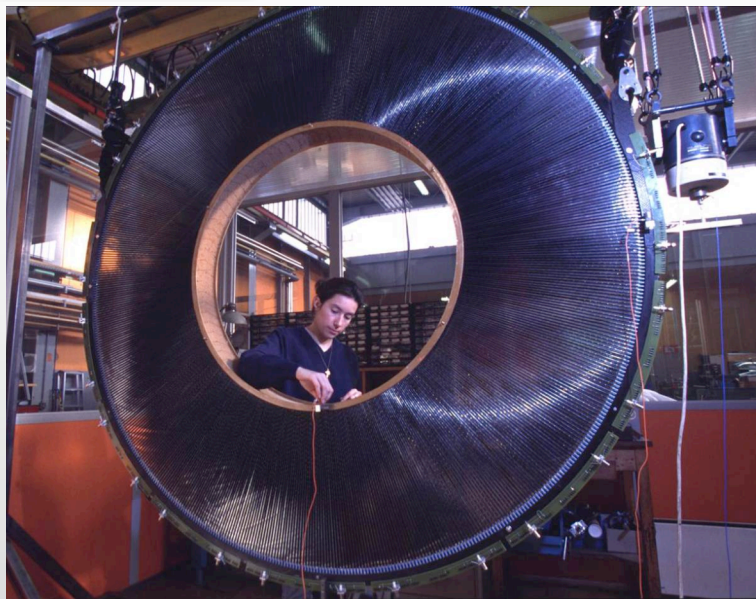
SCT precision studies with cosmics data:

- **Efficiencies:** above 99% in all layer
 - **Alignment:** After alignment a hit residual distribution with $\sigma = 30 \mu\text{m}$ has been obtained
- To compare with the design value $\sigma = 24 \mu\text{m}$

Frequency scanning interferometry (FSI) (absolute distance interferometry) will be used to monitor shape changes of the SCT allowing for $10 \mu\text{m}$ precision tracker shape corrections

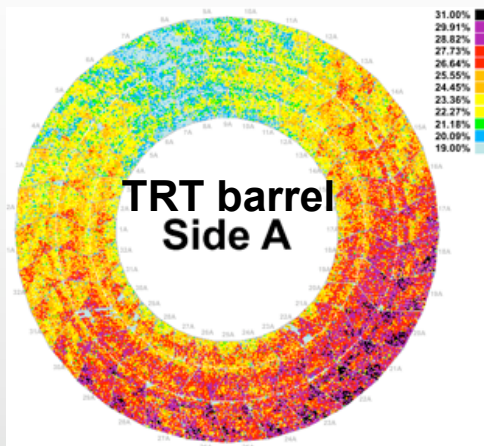


The Transition Radiation Tracker (TRT)

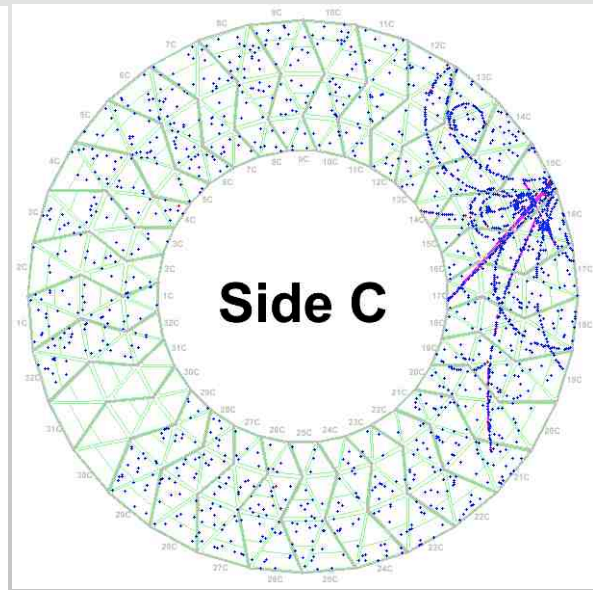
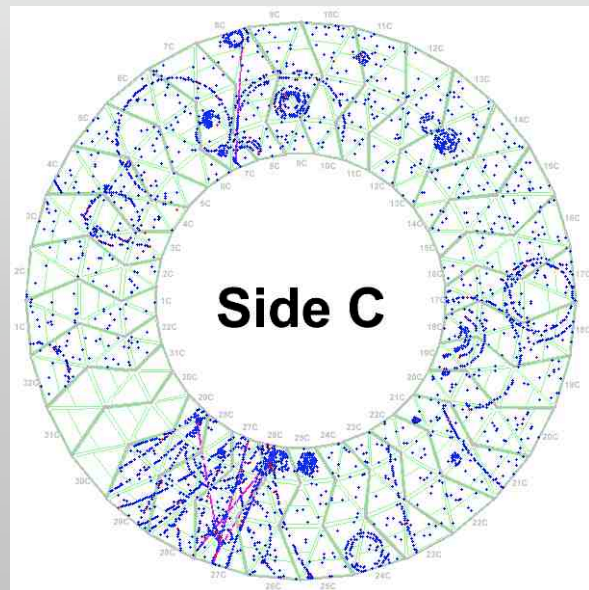


TRT Endcap module

Cosmics events as seen by the Barrel TRT detector:
A “bubble-chamber” quality track reconstruction!

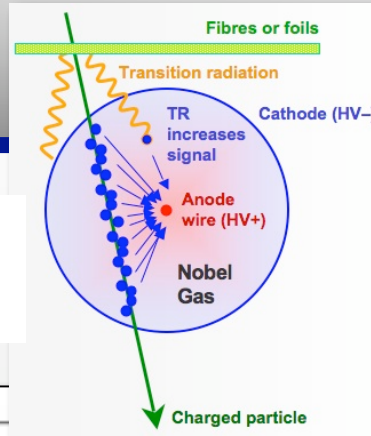


BEAM SPLASH event as seen by the Barrel TRT detector.
Almost all tubes were illuminated. Color scale gives the arrival time w.r.t. τ_0 's adjusted for cosmics



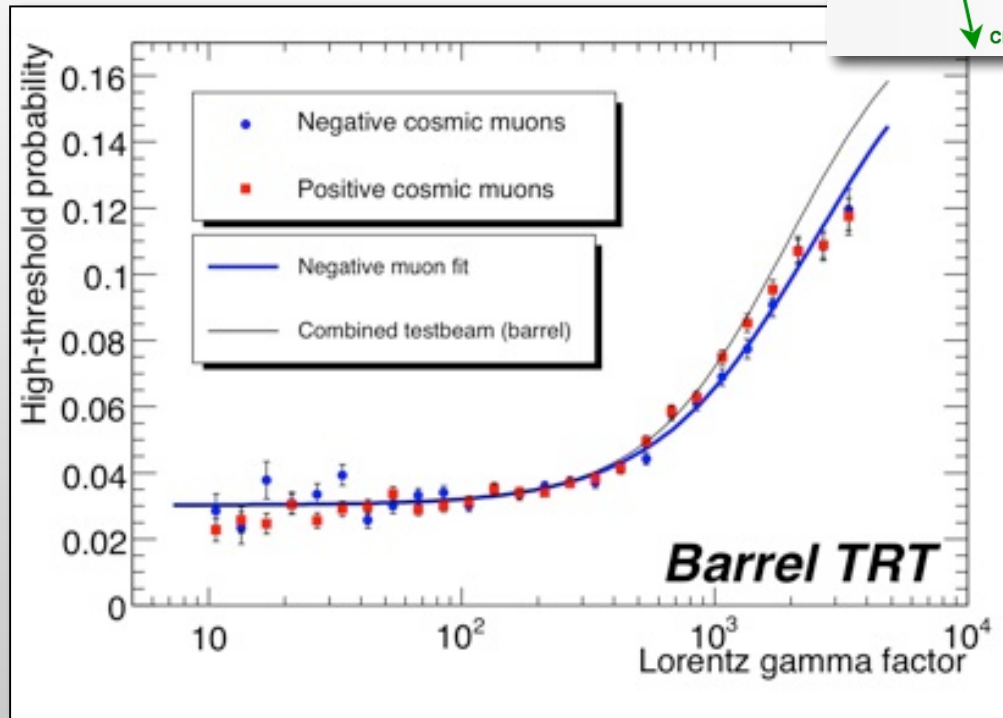
TRT Results

Transition Radiation threshold for high momentum muons



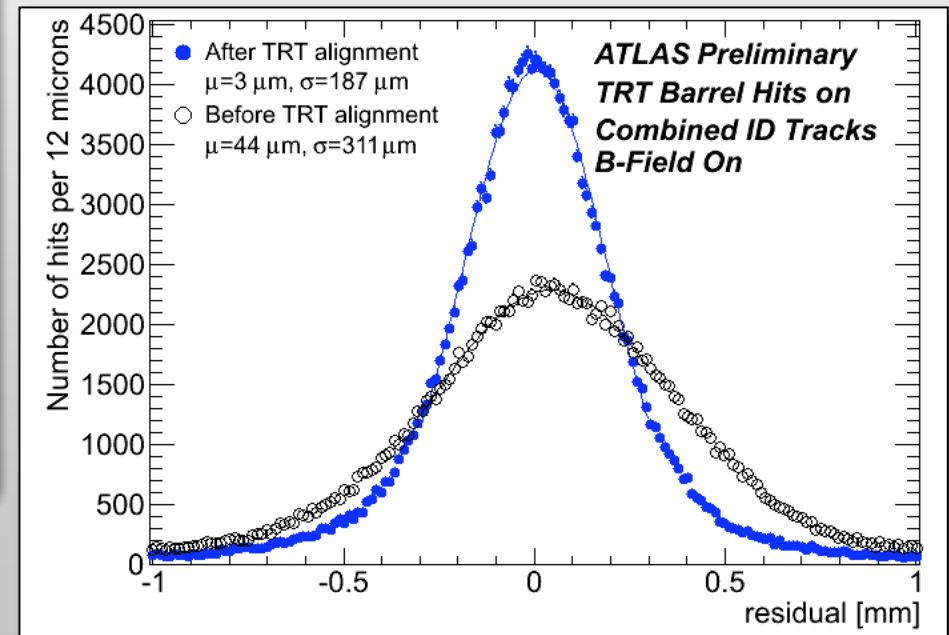
Different type of radiator materials:

- Barrel: polypropylene-polyethylene fiber mats ("chaotic" orientation of fibers/boundaries)
- End-caps: polypropylene foils ("aligned" orientation of boundaries).



Good agreements between Cosmics and Test Beam data

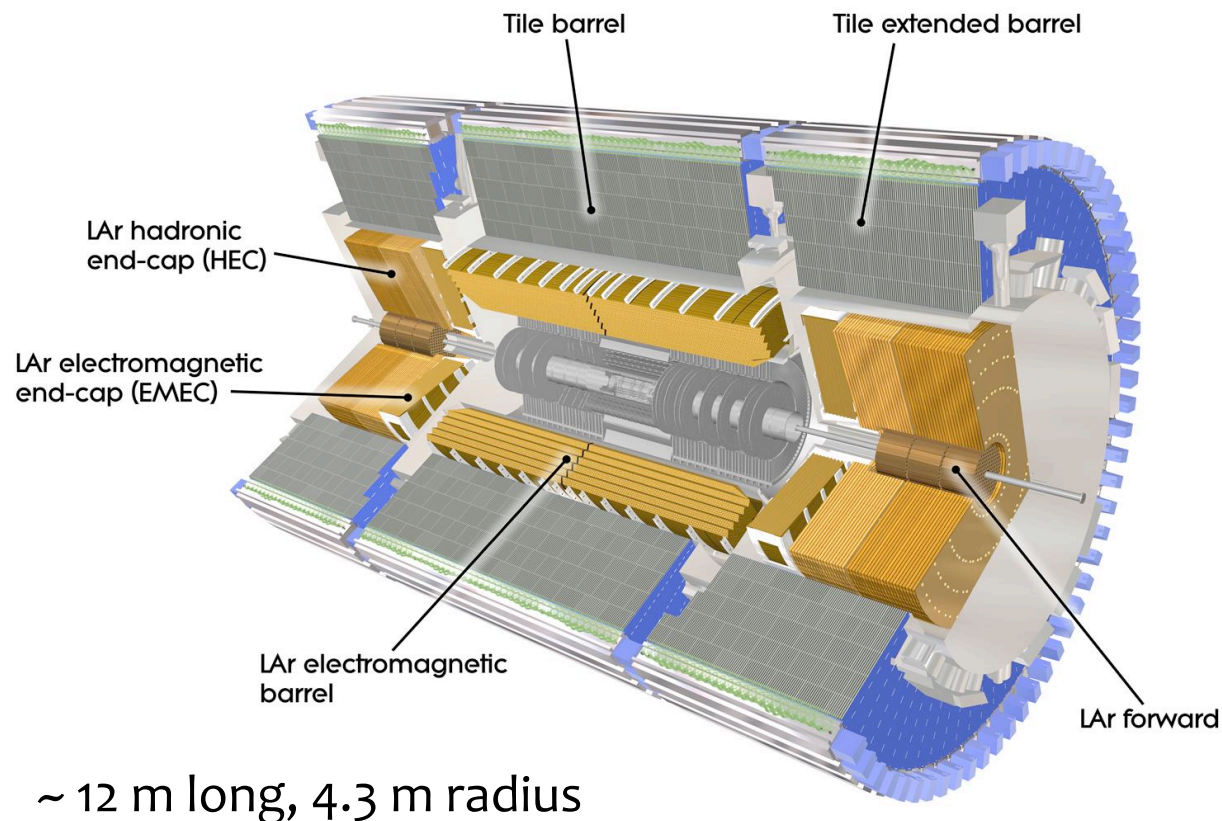
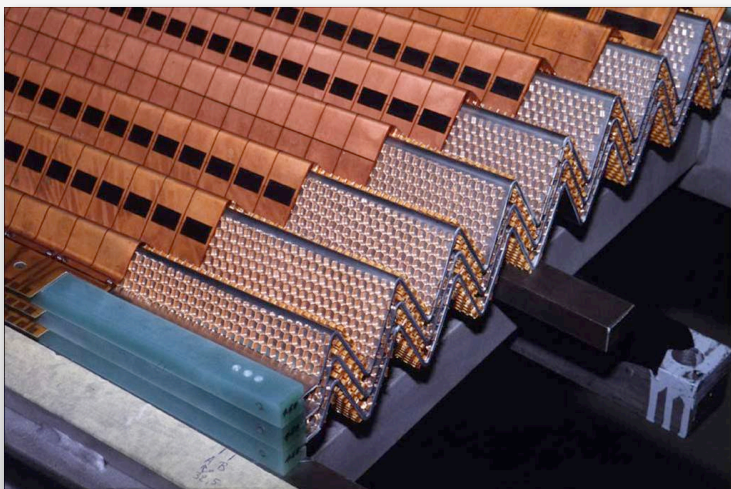
TRT alignment from Combined ID Tracks achieved $\sigma=187 \mu\text{m}$; design $\sigma=130 \mu\text{m}$



Calorimetry

LAr Electromagnetic ($|\eta| < 3.2$)

- Pb-LAr accordion structure

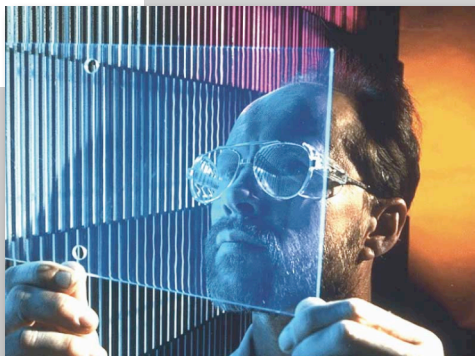


LAr Endcap Hadronic ($1.5 < |\eta| < 3.2$)

- Cu/W-LAr structure

Iron **Tile** Hadronic ($|\eta| < 1.7$)

- Fe-scintillating tile structure



Electromagnetic energy resolution:

$$\sigma(E)/E = 10\%/\sqrt{E} \oplus 0.7\%$$

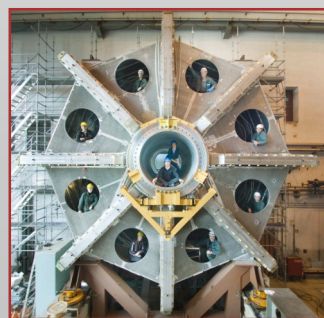
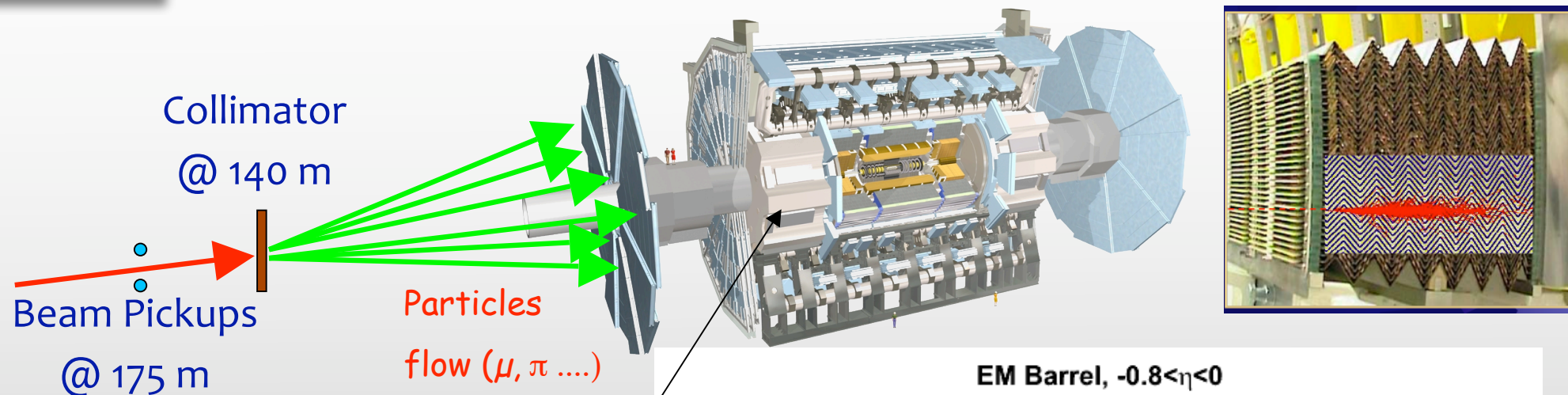
Hadronic energy resolution:

$$\sigma(E)/E = 50\%/\sqrt{E} \oplus 3\% \quad (\eta < 3.2)$$

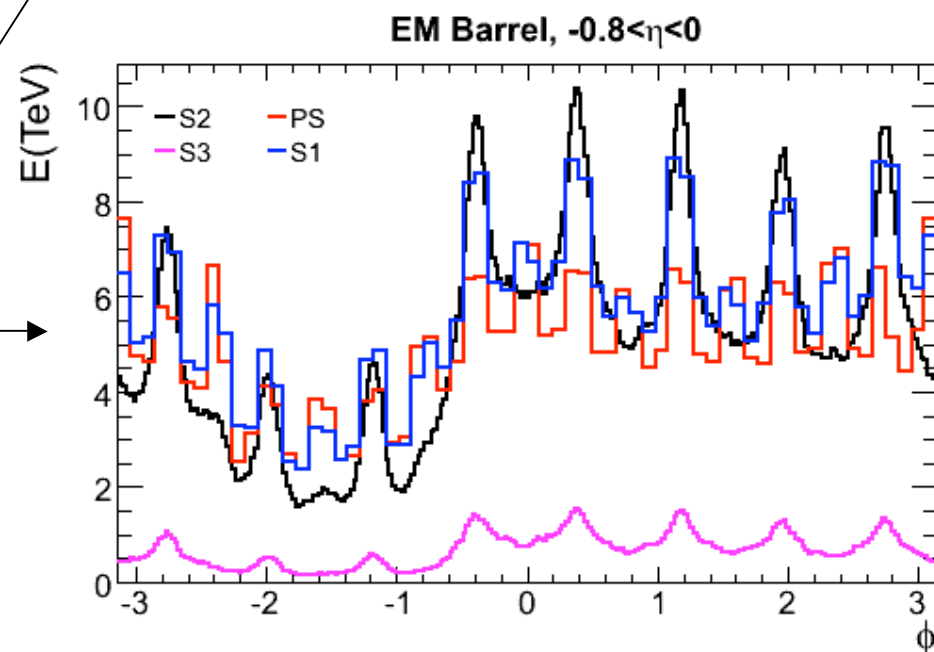
$$\sigma(E)/E = 100\%/\sqrt{E} \oplus 10\% \quad (\eta > 3.1)$$

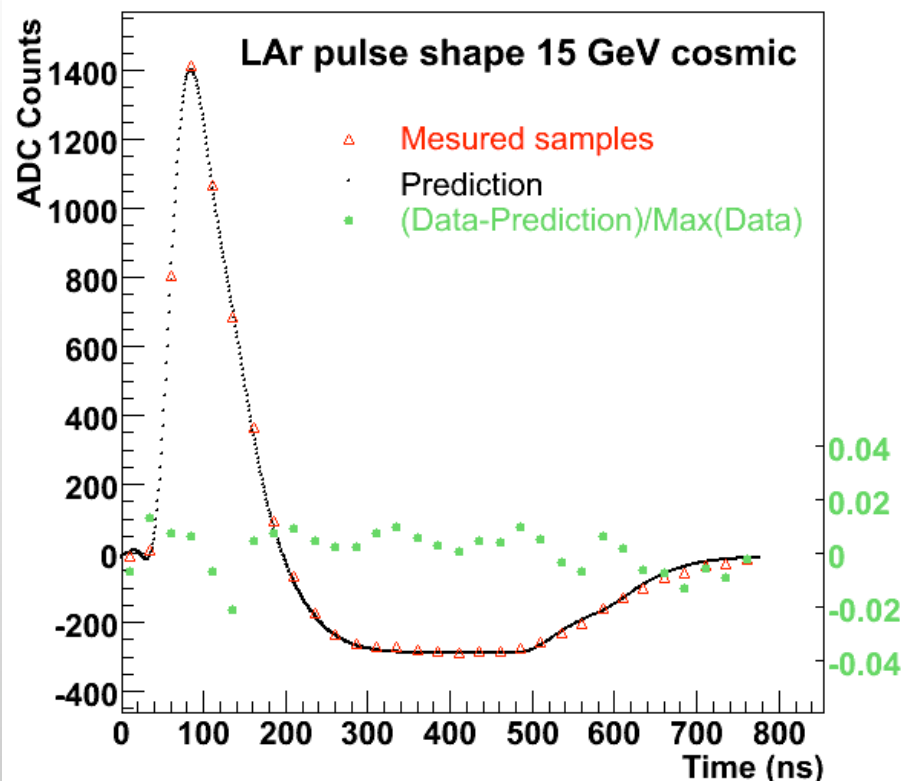
Trigger for e/γ , jets, missing E_T

LAr High Energy Deposit from Beam Splash Events

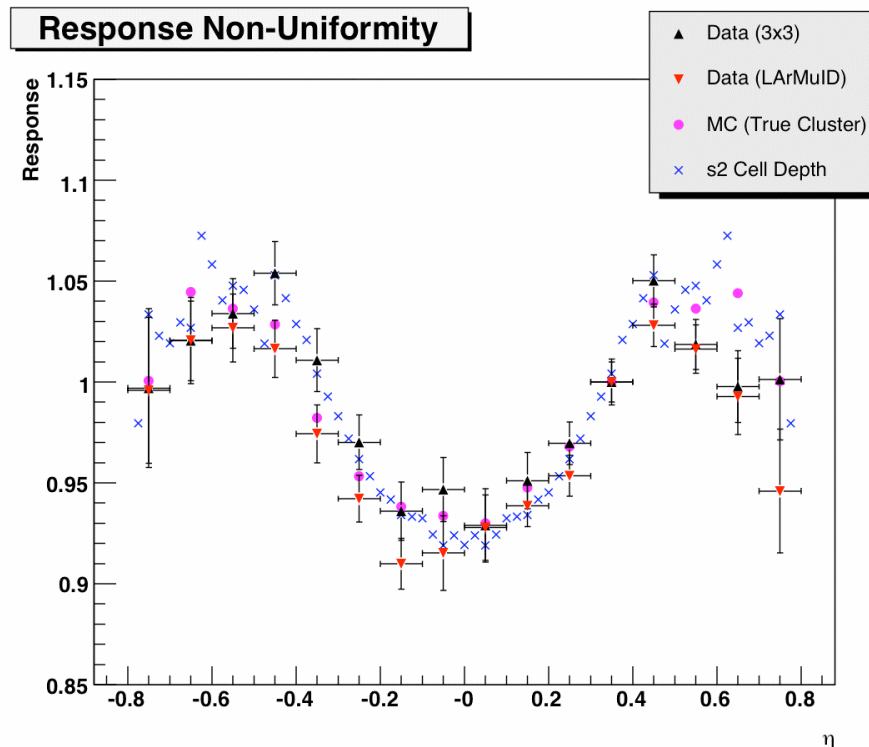


8-fold Φ
structures
from
endcap
toroid
shielding



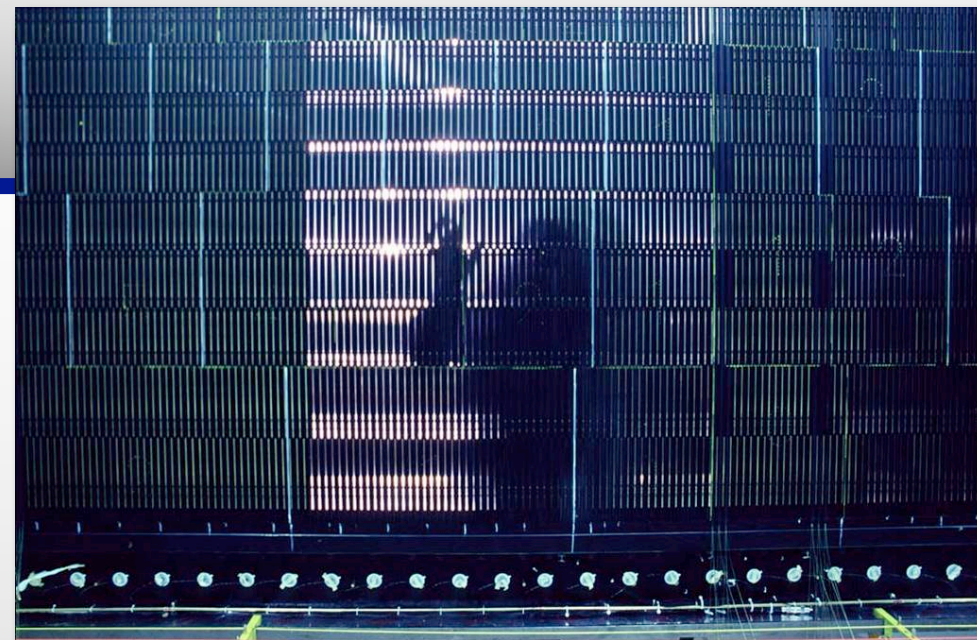
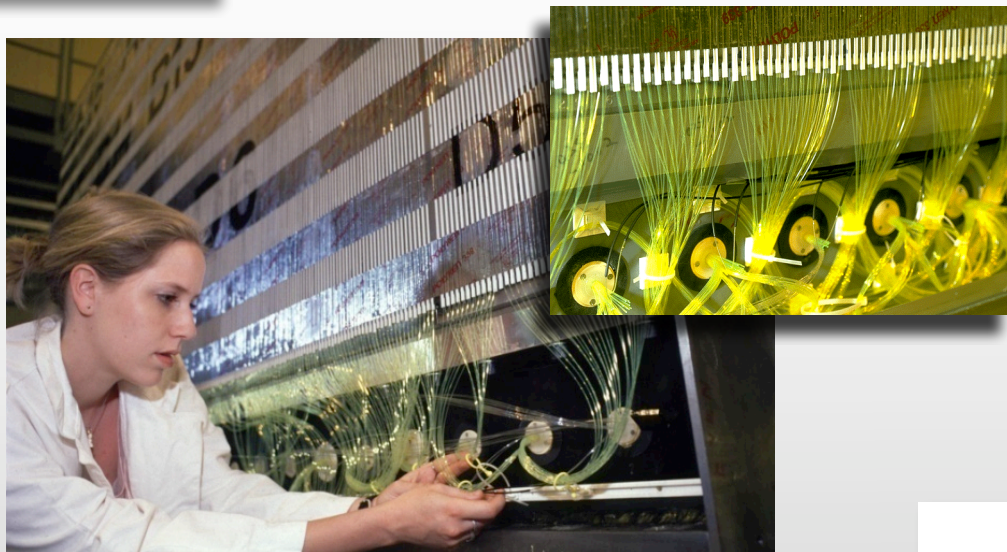


- A typical pulse for cosmic muon in the LAr EM Barrel, with 32 samples allowing to see the complete pulse shape (error on the measurement ~ 5 ADC)

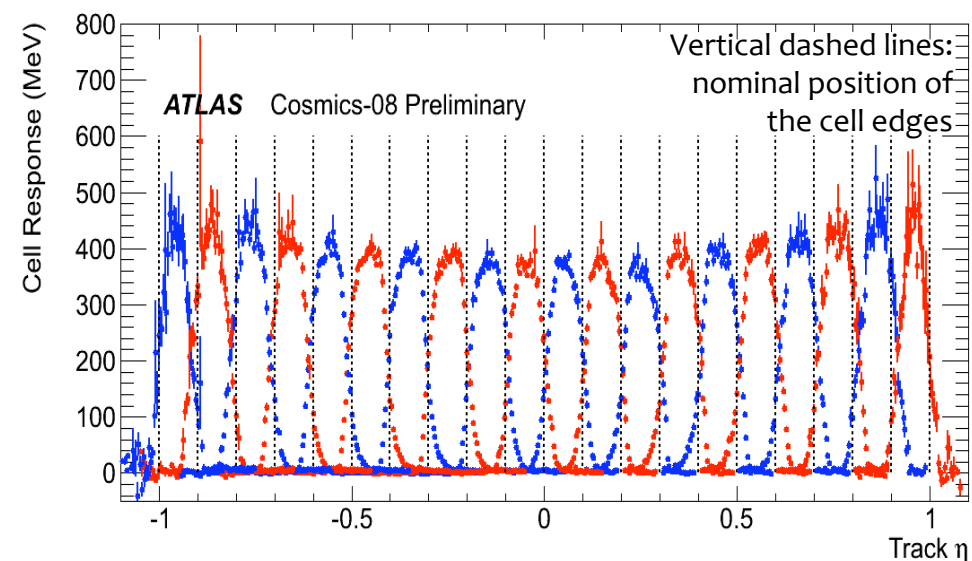
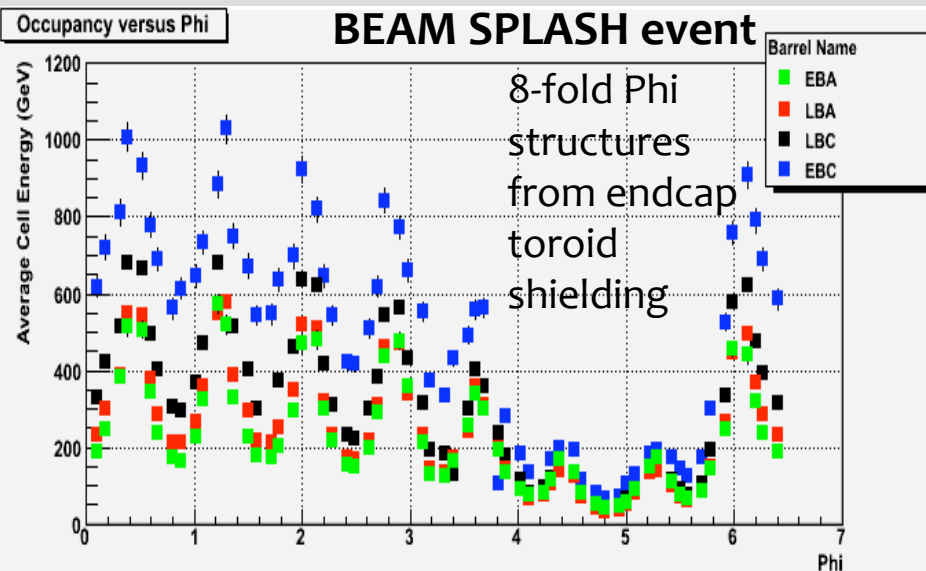


- Most Probable Value of LAr deposited energy distribution (normalized) as a function of η . Clearly tracks the cell depth as one would expect for a minimum ionizing particle

The Tile Calorimeter



Cell Energy deposit from Cosmics data



The Muon Spectrometer

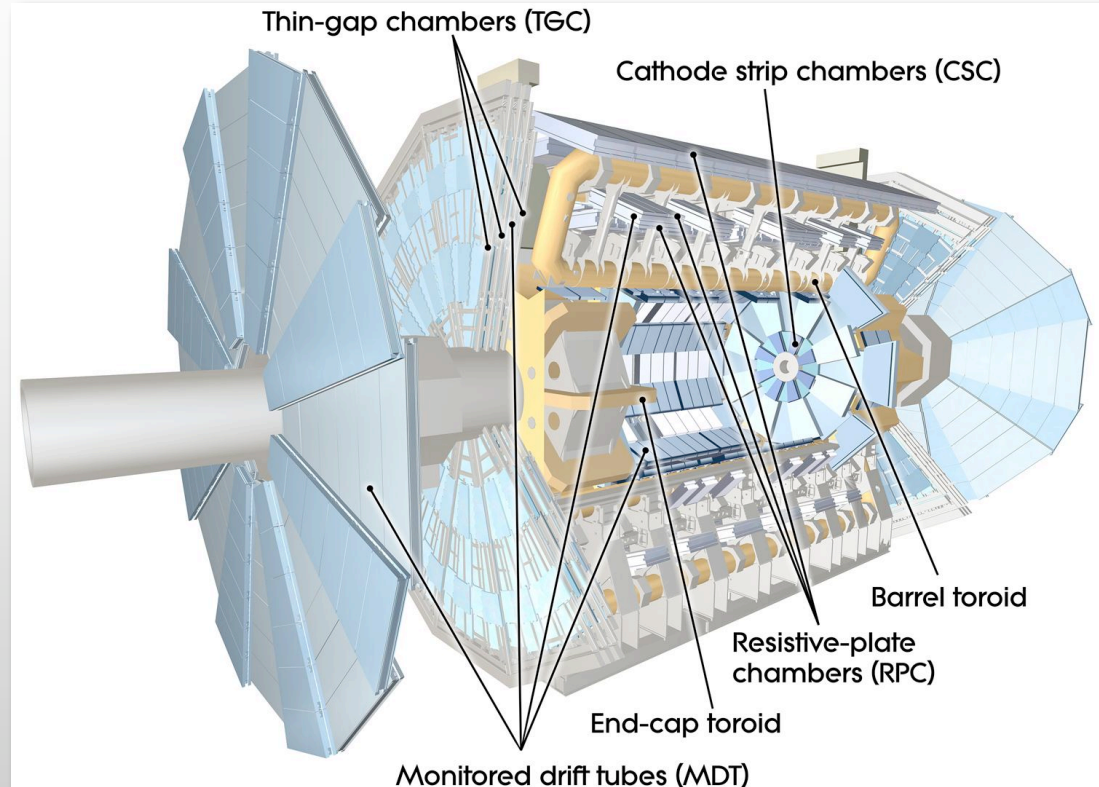
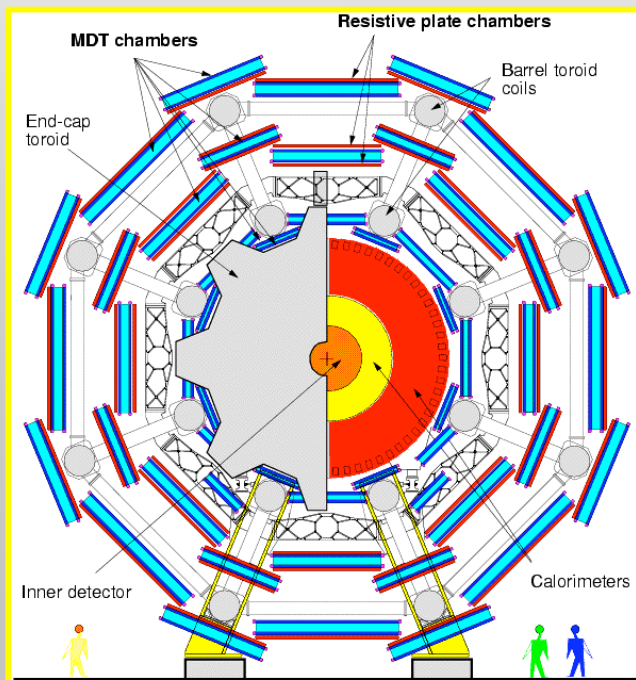
Three stations in a superconducting air-core toroidal magnetic field

Trigger in high background

- Barrel Trigger $|\eta| < 1.05$

Resistive Plate Chambers (RPC) 544 chambers 373k chan

- Endcap Trigger $1.05 < |\eta| < 2.7$ Thin Gap Chambers (TGC) 3588 chambers 318k chan

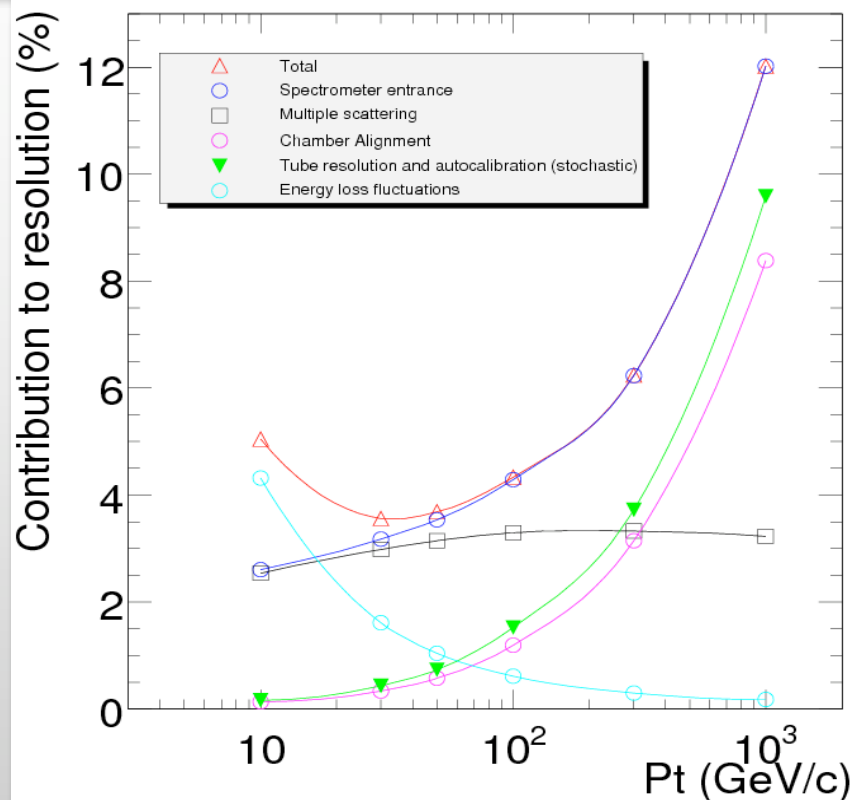


High precision muon reconstruction

- Monitored Drift Tubes (MDT) $|\eta| < 2.7$ 1088 chambers 354k chan
- In the Innermost station: Cathode Strip Chambers (CSC) $2 < |\eta| < 2.7$ 32 chambers 30.7k chan

TOTAL:
Over 10^6
channels

Muon Spectrometer - momentum resolution



- $\Delta p_T/p_T < 3\%$ in 15 - 200 GeV interval
~ 10% at 1 TeV

• **Calibrations and alignments**
should have precision of $\sim 30 \mu\text{m}$

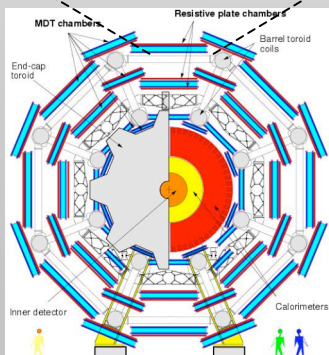
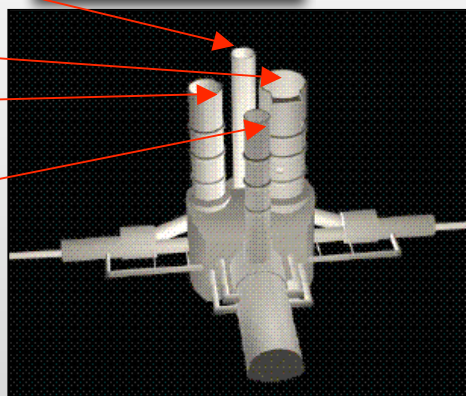
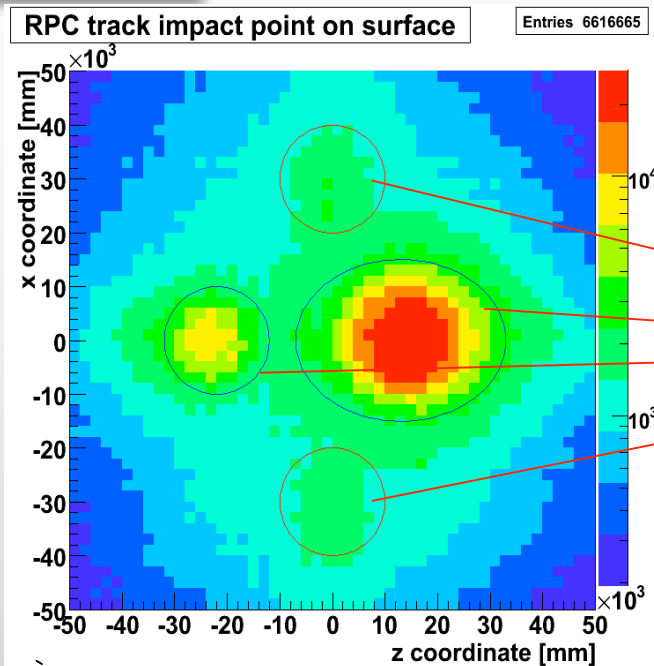
Muon trajectories are measured in 3 stations (Inner, Middle and Outer) immersed in a toroidal magnetic field

- **single point MDT average resolution:**
 $\sim 80 \mu\text{m}$
- 6/8 measurements points per chamber
- 3 measurement stations

Dominant contributions:

- $p_T < 25 \text{ GeV/c}$ fluctuations in energy loss in the calorimeters
- $p_T = 25 - 300 \text{ GeV/c}$ multiple scattering in the spectrometer
- $p_T > 300 \text{ GeV/c}$ Sagitta error measurement (MDT tube resolution, calibrations, alignments)

The Resistive Plate Chambers with COSMICS DATA



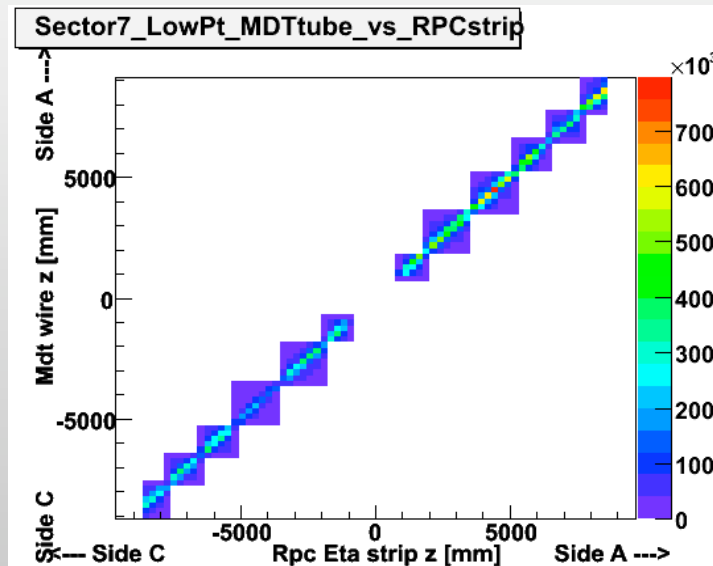
RPC cosmics muon tracks
projected onto cavern surface
(81 m)

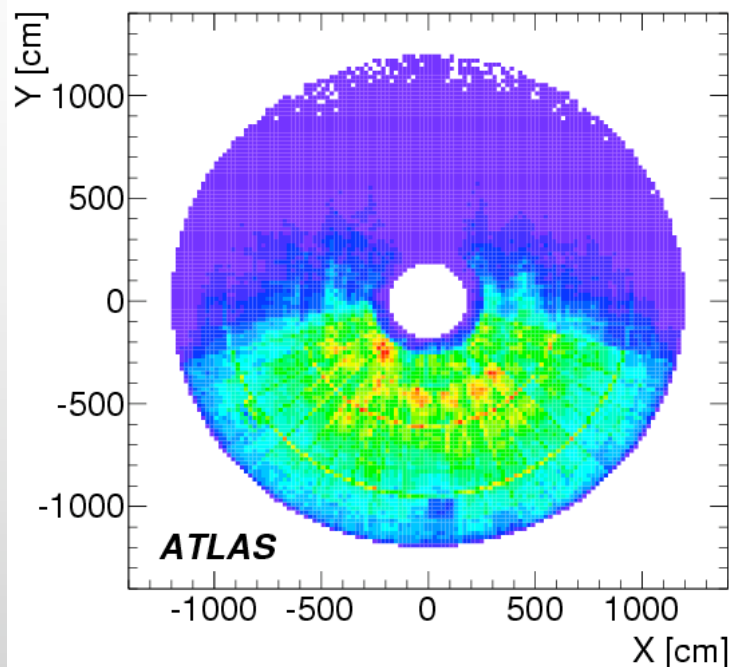
Visible:

2 access shafts

2 lifts (ignored in simulation)

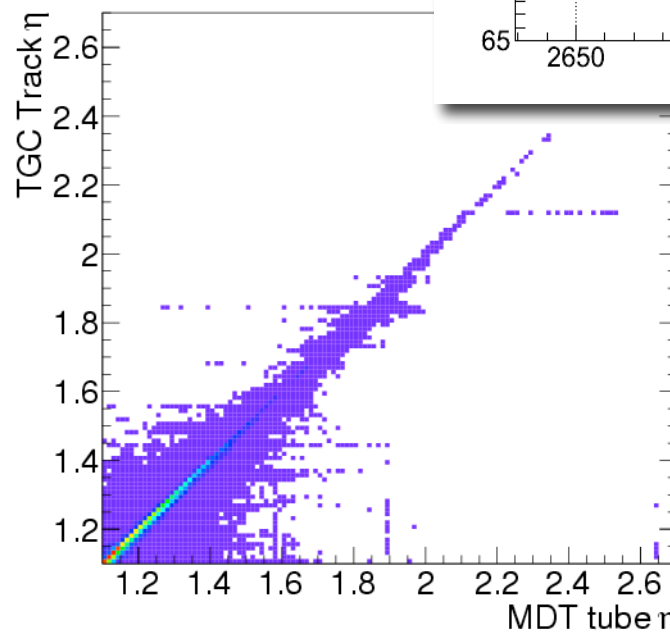
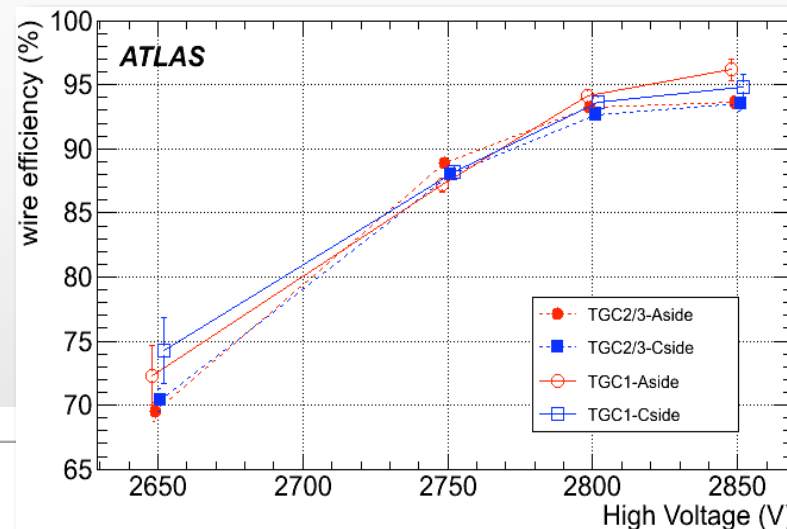
Very good correlation
between MDT tube hits
and RPC eta strips



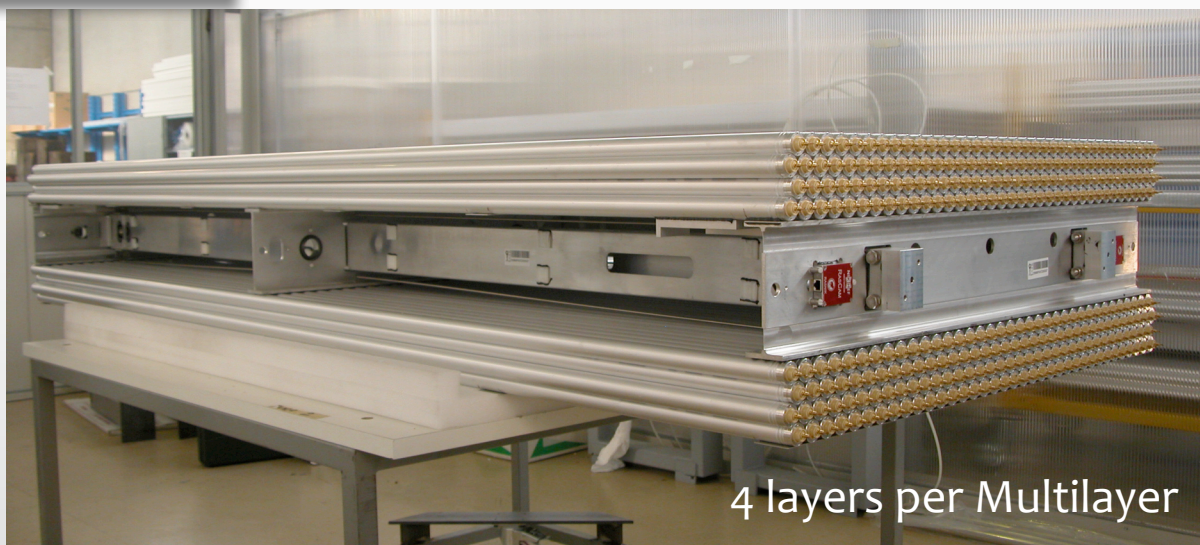


TGC hits distribution in x-y plane Hit positions from coincidence of wire eta hits and strip phi hits. Only bottom sectors are used for triggering

TGC layer efficiency as a function of applied High-Voltage



Correlation btw MDT tube hits in middle station and TGC track interpolated to MDT middle station

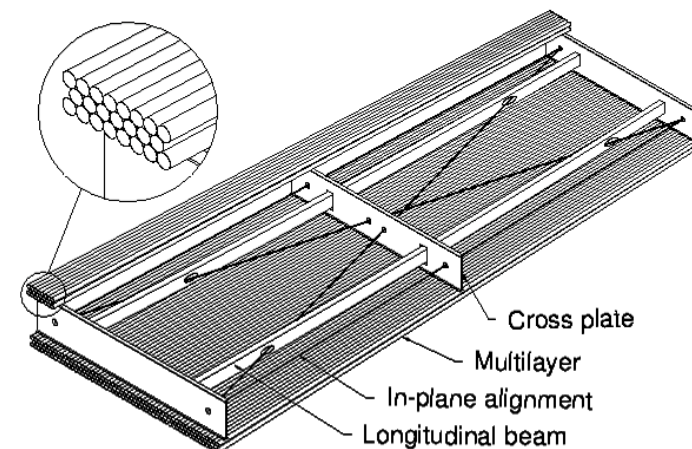


4 layers per Multilayer

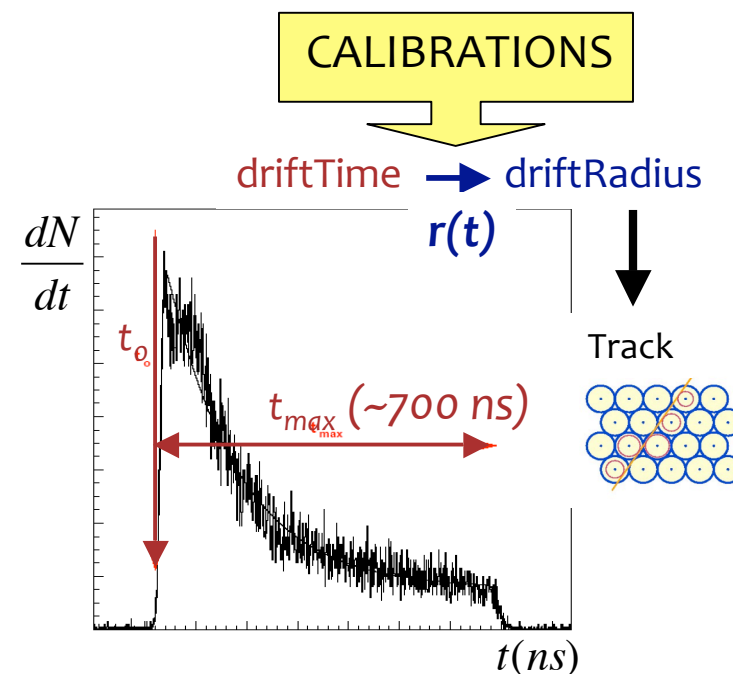
MDT (Monitored Drift Tubes)
PRECISION TRACKING CHAMBERS
Two Multilayers of 3 cm diameter
drift tubes
Gas: 3 bar 93%Ar 7%CO₂
Single point resolution ~ 80 μ m
Maximum drift time ~ 700 ns

Need good
precision of
 $r(t)$ relation
(20 μ m)

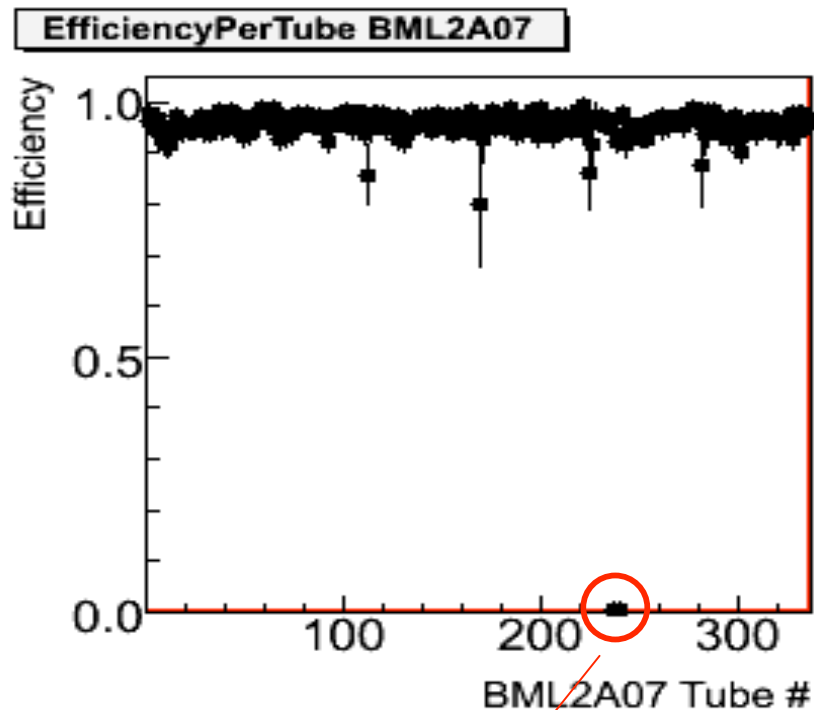
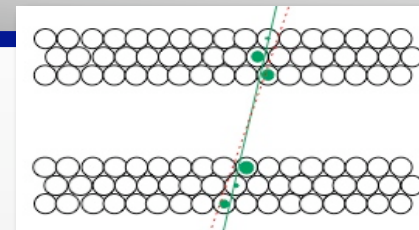
CALIBRATIONS
continuously
monitored



3 layers per Multilayer



MDT Results: Hit Efficiency and Residuals

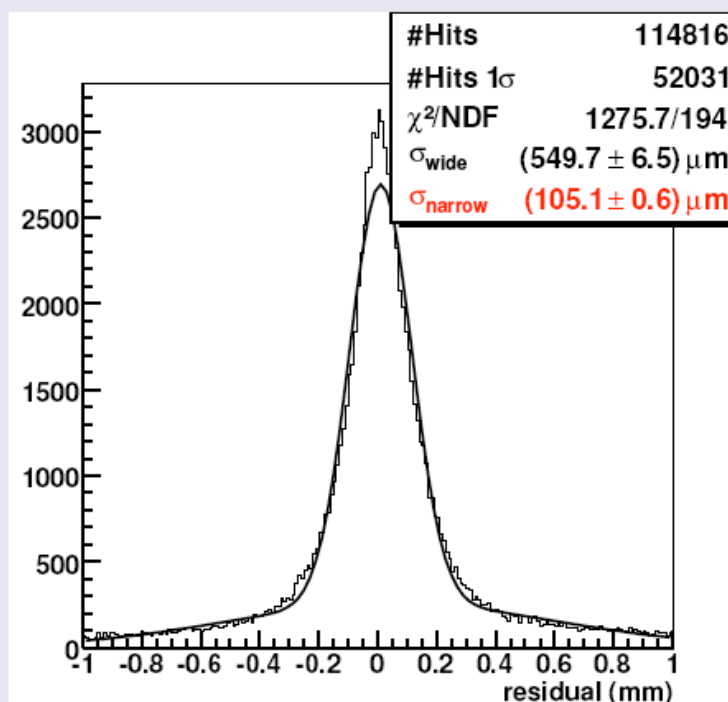


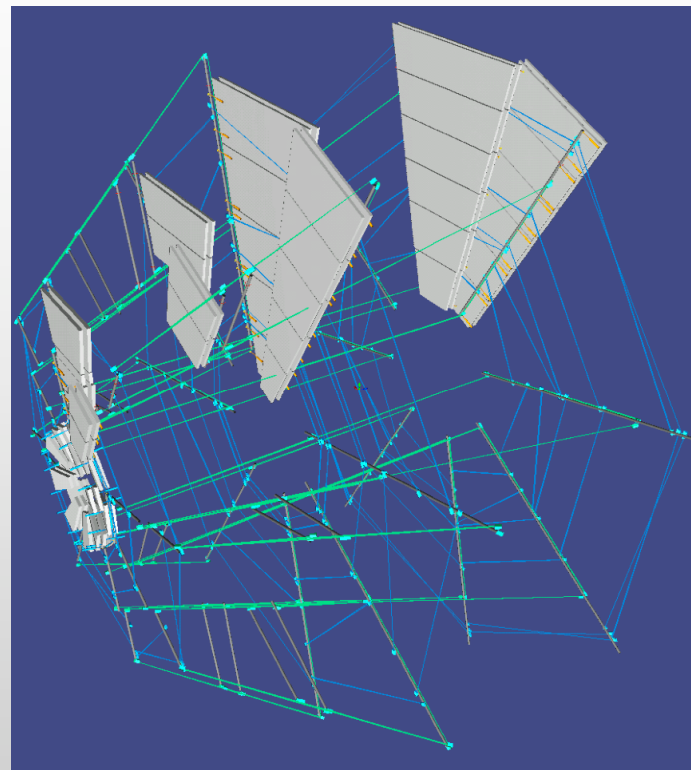
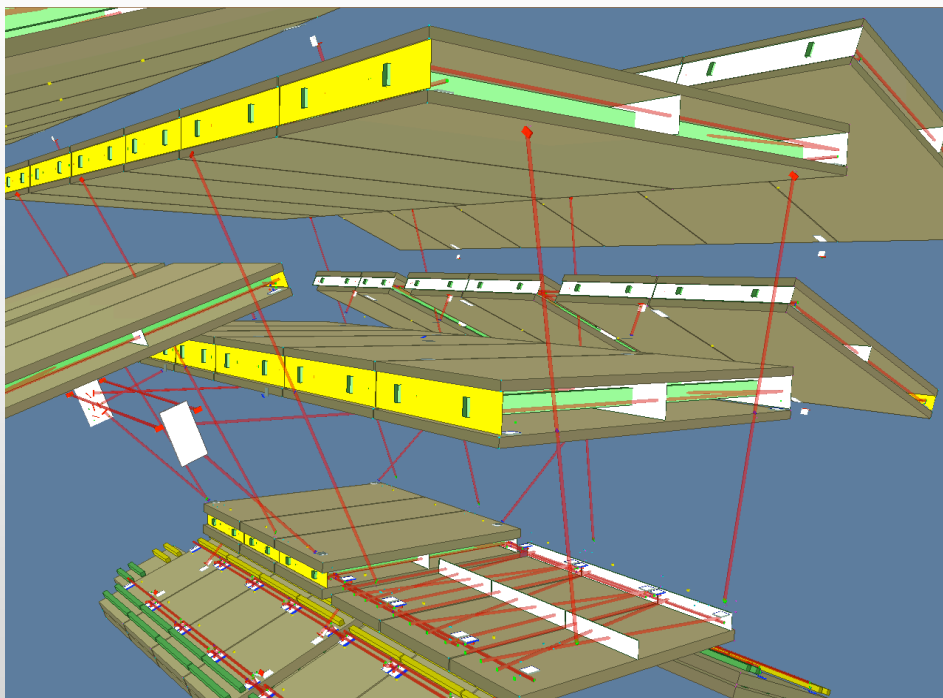
- 0.1% single dead channels
- 1% clustered dead channels (being fixed)
- Noisy channels ($> 5\%$ occupancy) $< 0.2\%$

• **Tube Efficiency:**
Comparable to Test Beam measurements

• **Hit on segments residuals:**
At $100\ \mu\text{m}$ level

External Refit





Design Vs Observed alignments:

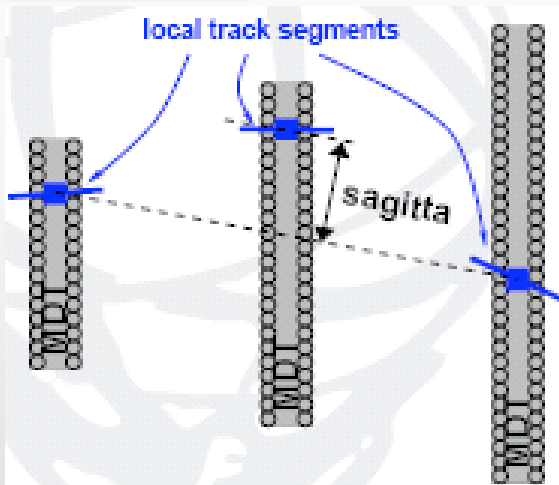
Optical system alignment designed to provide muon tracking chamber positions with a sagitta accuracy of $30 \mu\text{m}$

Observed (absolute position):

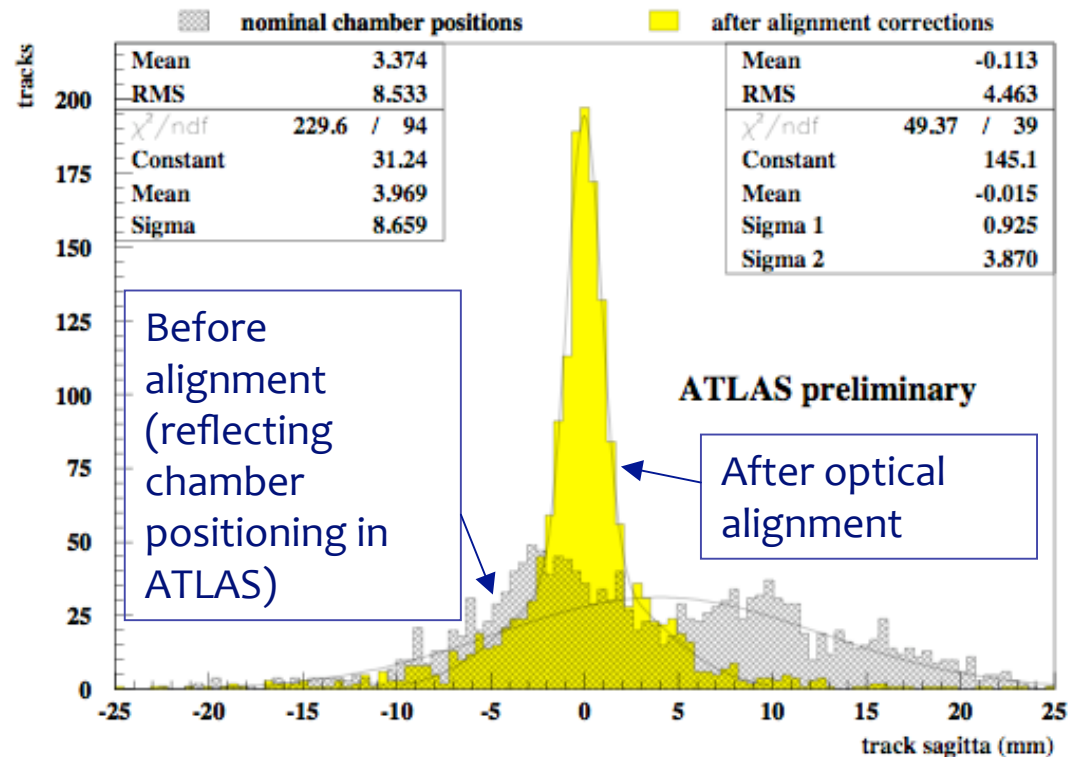
$45 \mu\text{m}$ in the endcap and $200 \mu\text{m} - 1 \text{ mm}$ in the barrel (small/large sectors)

Changes of position with time will be followed at $<30 \mu\text{m}$ accuracy

Muon Track based alignment is needed to provide initial chamber positions and to reach ultimate goal of $30 \mu\text{m}$ in the barrel



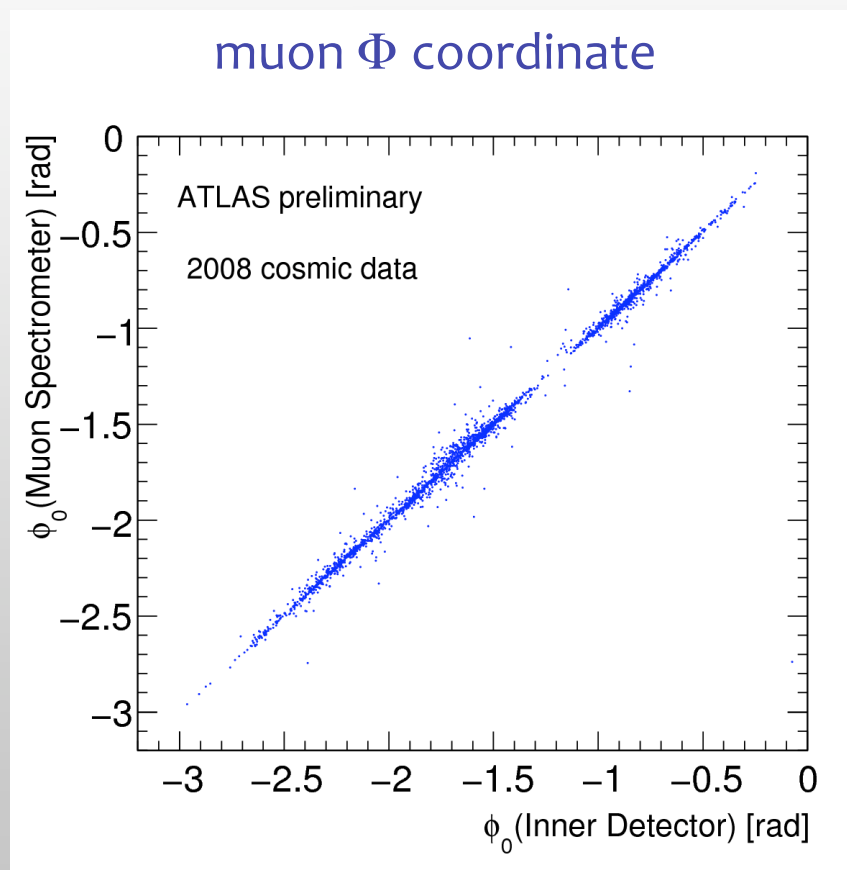
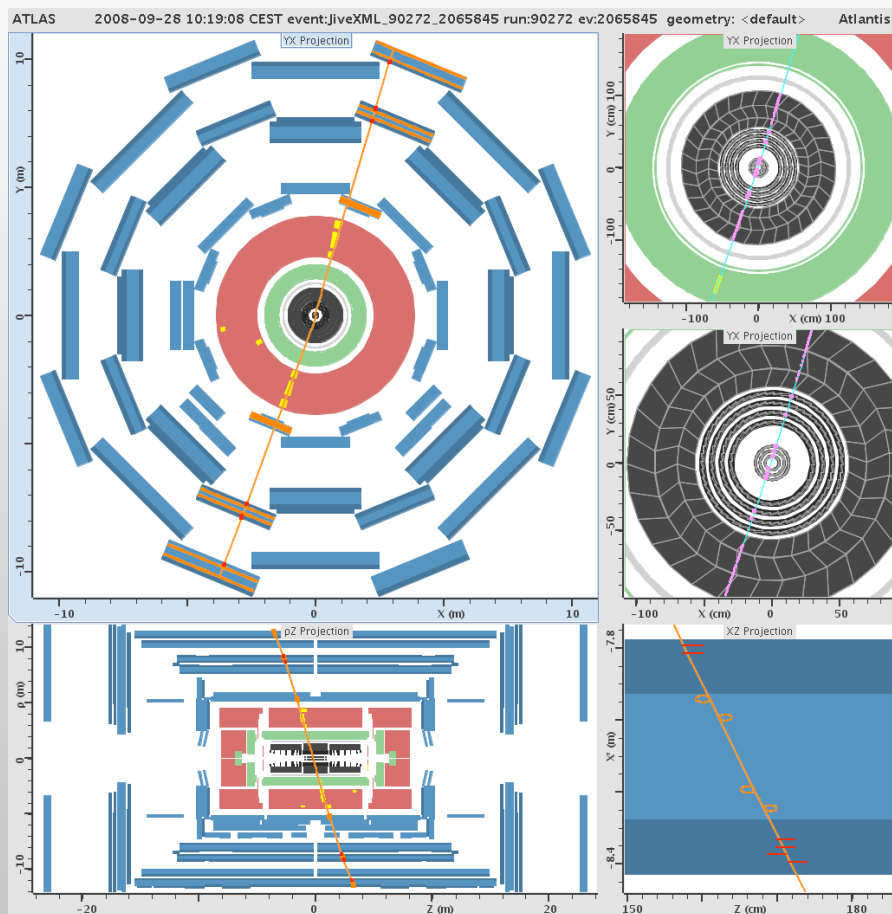
- Straight cosmic muons (Bfield OFF) data used to compute sagitta
- Sagitta calculated from track segments
- For perfect alignment:
 - zero mean value
 - width dominated by multiple scattering



- sagitta residuals within the design specification
- OPTICAL system performs well.
- It is overconstrained in the Endcap

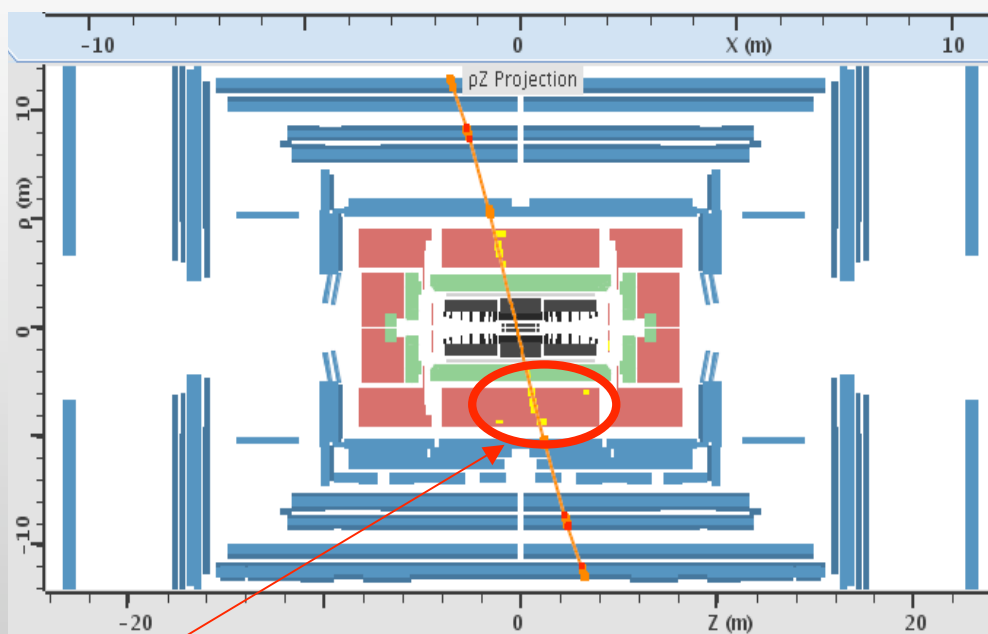
Muon Combined INNER Detector Vs Muon Spectrometer

Correlations between measurements in the Inner Detector and in the Muon Spectrometer



Muon Combined INNER Detector Vs Muon Spectrometer

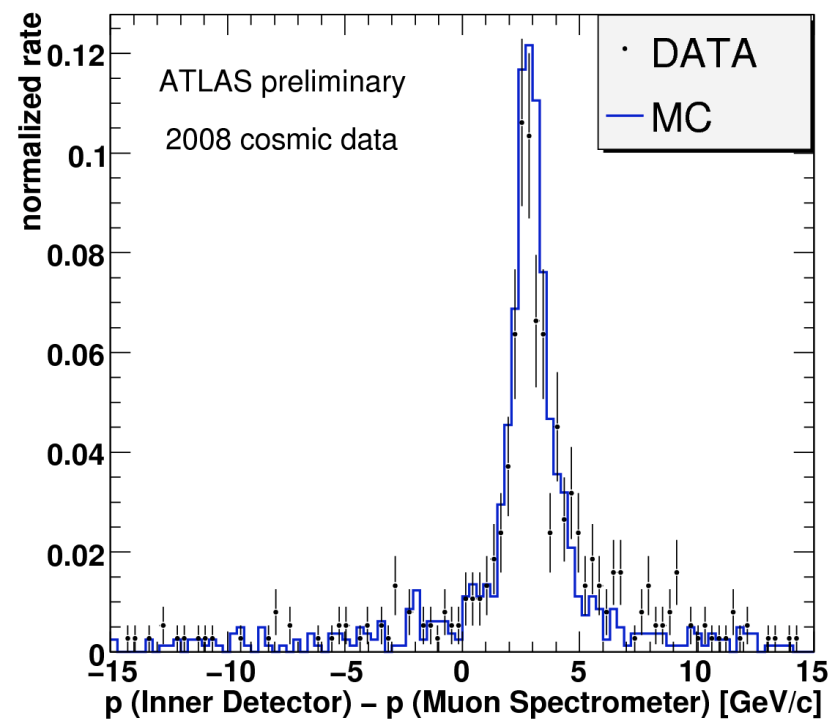
Correlations between measurements in the Inner Detector and in the Muon Spectrometer



Muons crossing the calorimeters

The difference of 3 GeV/c corresponds to the expected energy loss of a muon crossing the calorimeters

Difference between the muon momentum in the ID and the MS for tracks in the bottom part of the detector



Achievements with cosmics (and with little beam time) and ATLAS detector Status

System	Fraction of working detector (%)
Pixel	98.5
SCT	~99.5
TRT	>98
Lar EM	99.5
Lar HEC	99.9
Lar FCAL	100
Tile	99.5
MDT	99.3
TGC	>99.5
RPC	~95.5

- Timing of the various detectors to within a few ns.
- The MUON Spectrometer is providing trigger and tracking with close to its final resolution for the rapidity range up to $\eta < 2.0$
- The TRT has shown its Transition Radiation characteristics to perform its share in electron identification.
- The calorimeters are providing the full coverage, with the expected performance (for cosmics), and a negligible number of non-working channels.
- The Inner Detector, with all its complexity, is approaching its expected performance

ATLAS IS READY FOR COLLISIONS!

Early Physics Measurements with ATLAS

FIRST DATA and FIRST MEASUREMENTS

- **Understanding the detectors and measuring the main Standard Model physics processes must proceed hand in hand: these two aspects are highly correlated**

Most urgent goals as soon as first collisions become available:

- Commission the detectors and triggers in LHC environment, tune software tools
 - at beginning: **minimum bias and QCD jet**
 - at a later stage: use gold-plated **Z → ll** channel for detailed studies
- Perform extensive measurements on the main SM physics processes at $\sqrt{s} = 14$ (10) TeV (W, Z, dilepton distribution, ttbar, ...)
 - Typical initial precision for cross sections mainly limited by systematic uncertainties (acceptances, efficiencies and Luminosity) in the order of 10%

ATLAS Physics in 2009/2010

few pb^{-1}

- Detector synchronization (Trigger, timing studies)
- Initial detector alignments and calibrations
 - dilepton distributions (J/Psi, Upsilon)
- Minimum bias physics
- Jet physics

...

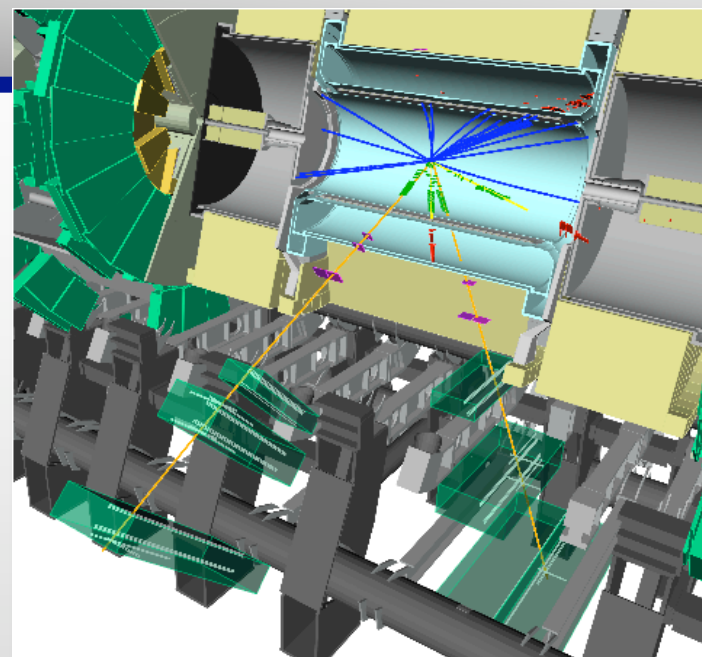
10 pb^{-1}

- More accurate detector calibration and alignments
- Muon Spectrometer Performance with Z, W
- Calo Energy scale, ETmiss calibration
- Z,W cross sections
- ttbar signals (cross section at 10-20%)

...

100 pb^{-1}

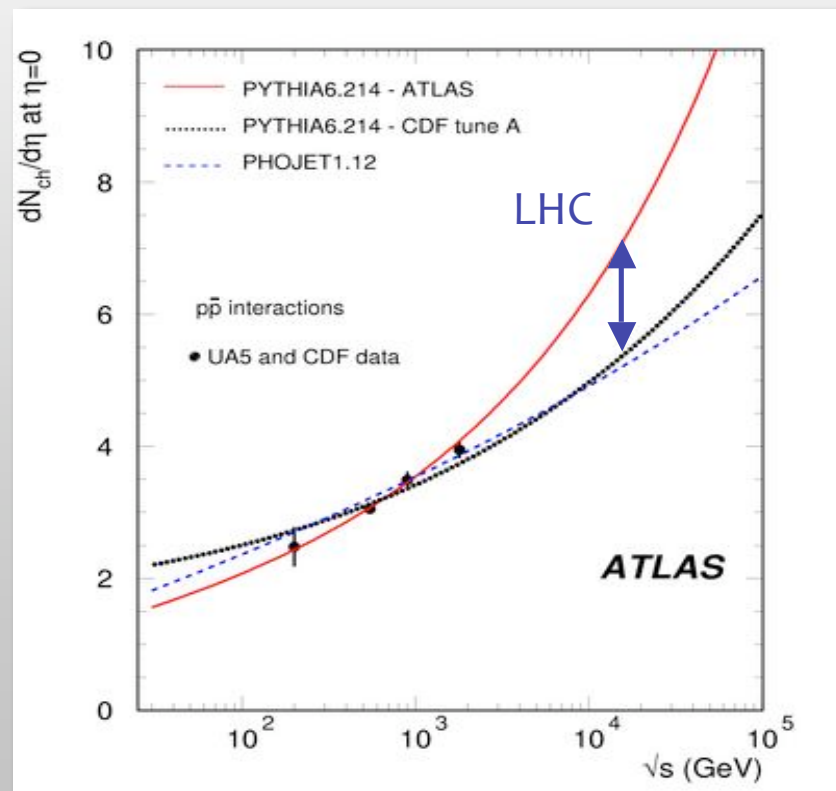
- Entering Higgs and SUSY discovery era !



Process	$\sigma(\text{nb})$ @ 10 TeV	$\sigma(\text{nb})$ @ 14 TeV
Min Bias	$\sim 10^8$	$\sim 10^8$
bb	$\sim 10^7$	$\sim 10^7$
Inclusive jets $p_T > 250 \text{ GeV}$	~ 50	~ 100
$W \rightarrow l\nu$	14.3	20.5
$Z \rightarrow ll$	1.35	2.02
tt	0.4	0.83

Minimum Bias Physics with $\sim 1 \text{ pb}^{-1}$

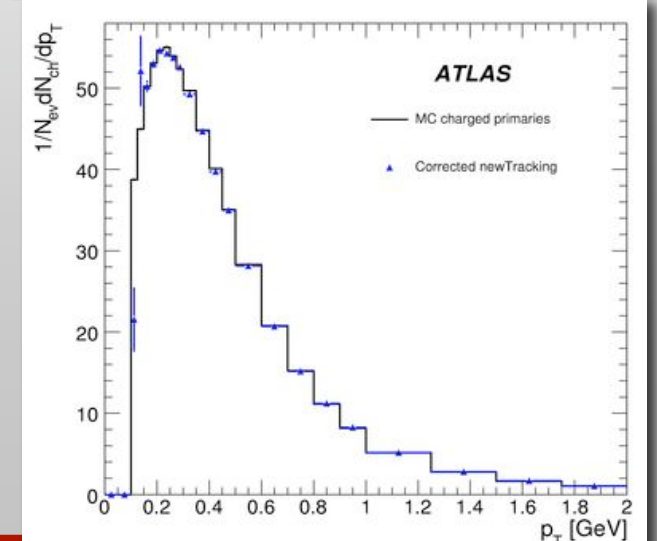
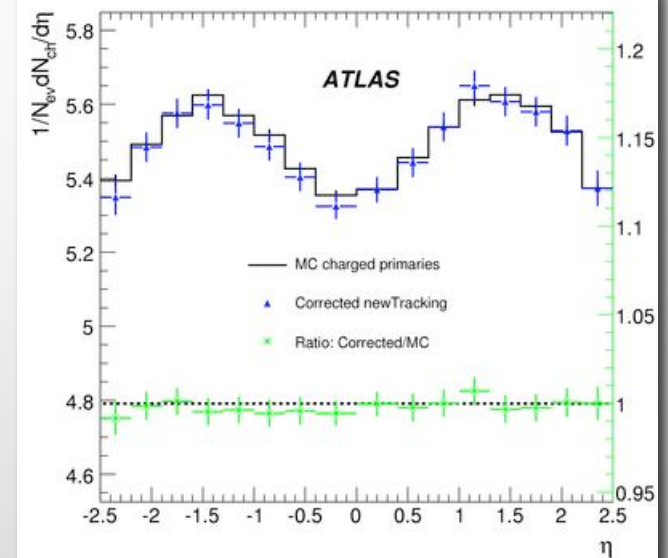
Averaged charged particle multiplicity at $\eta=0$ in minimum-bias events. Predictions differ significantly at LHC energies



The pseudorapidity (η) and transverse momentum (p_T) distributions of charged particles.

Strong dependence on the adopted model

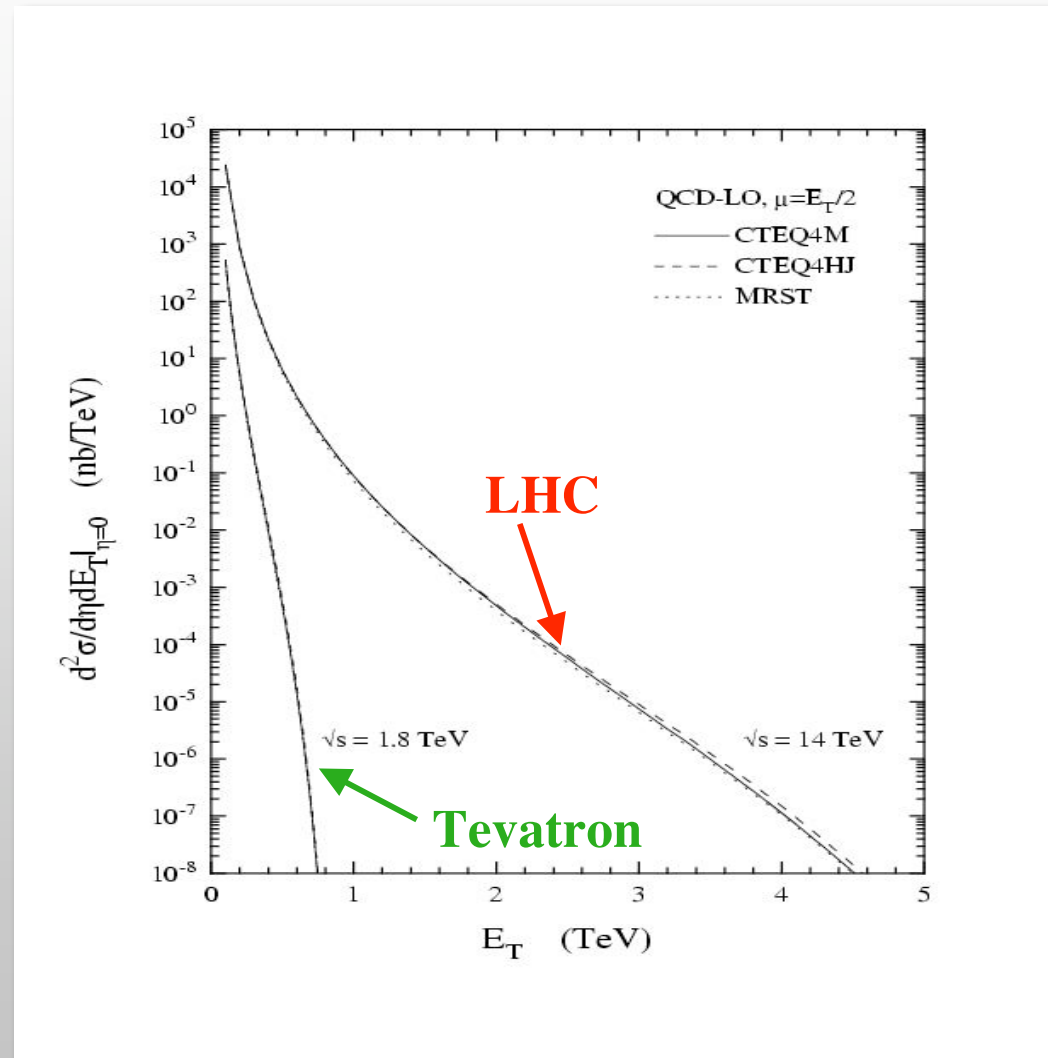
Systematic uncertainties initially estimated at 8% level dominated by ID alignment (6%). Still sufficient in order to distinguish between different models of minimum bias events



QCD Jet cross section

QCD jets abundantly produced at LHC

- $O(100)$ events with $E_T > 1$ TeV produced with 10 pb^{-1}
- Can rapidly probe the new Energy scale territory
- Background to most searches: accurate reconstruction and calibration essential



Dilepton production with $\sim 10 \text{ pb}^{-1}$

FIRST PEAKS will be seen in dilepton low-mass resonance region

- At 10 TeV, after all cuts (trigger and offline selection; two trigger considered: $\mu 4 \mu 4$, $\mu 4 \mu 6$):

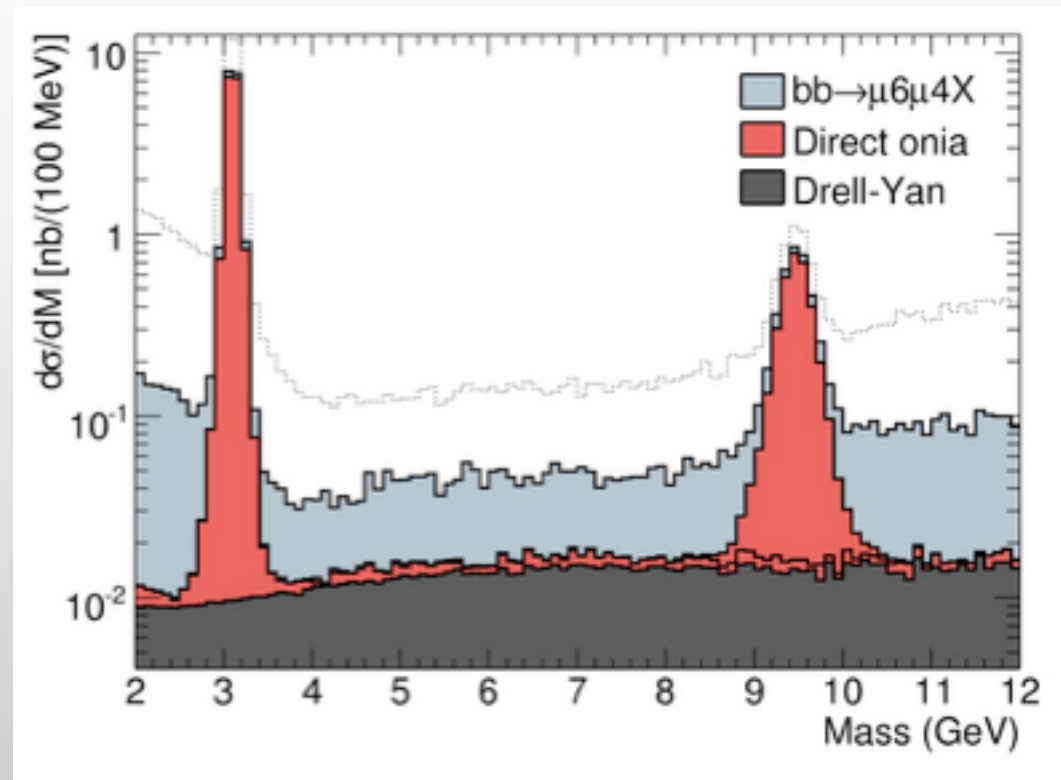
Nr. Events per 10 pb^{-1}

$$J/\psi \rightarrow \mu(4)\mu(6) \sim 90\text{K}$$

$$J/\psi \rightarrow \mu(4)\mu(4) \sim 110\text{K}$$

$$Y \rightarrow \mu(4)\mu(4) \sim 5000$$

- Sufficient statistics for tracker momentum scale, trigger performance, individual detector efficiencies



The cumulative plot of the invariant mass of di-muons from various sources, reconstructed with a $\mu 6 \mu 4$ trigger (muons with $p_T > 4$ (6) GeV)

Z, W reconstruction with 50 pb⁻¹

- Abundant production at LHC allows for early measurement of the cross section.

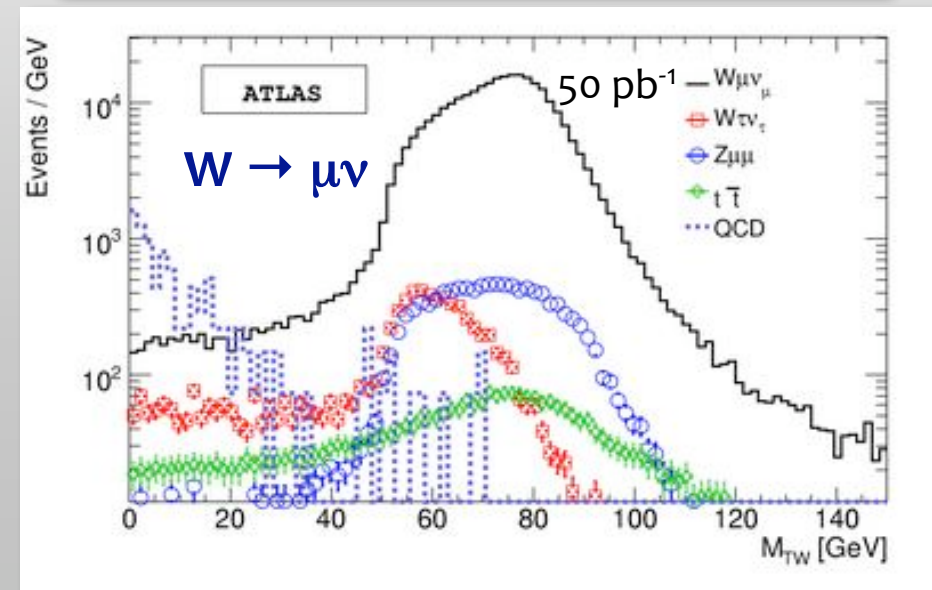
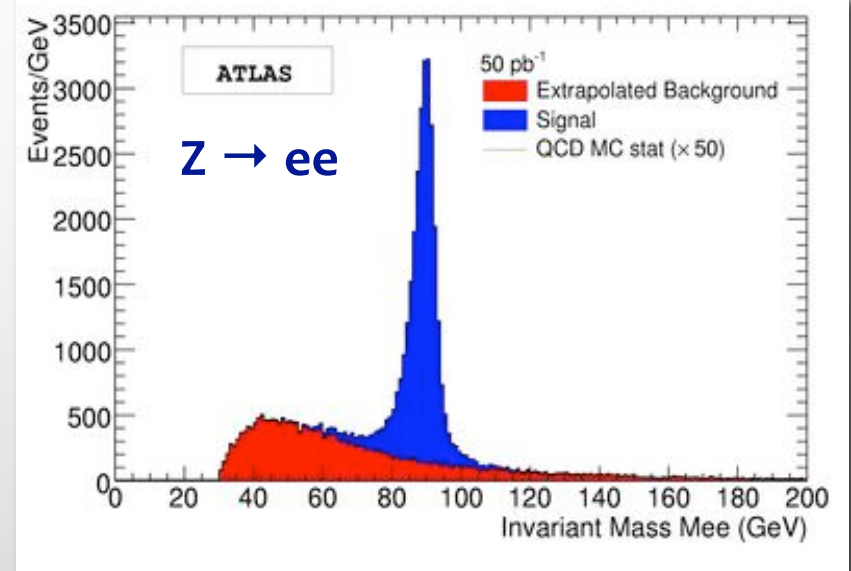
With 50 pb⁻¹ :

- O(10⁴) Z → μμ and Z → ee
- O(10⁵) W → μν and W → eν

- Leptonic final states provide a very clean signature

- Z → ll very important to understand and improve the detector performance (calibrations, momentum and energy scale, alignments)

- Cross section precision at ~1 % (stat.)
~2-4 % (syst. excluded luminosity)
(syst. contribution from luminosity ~10%)

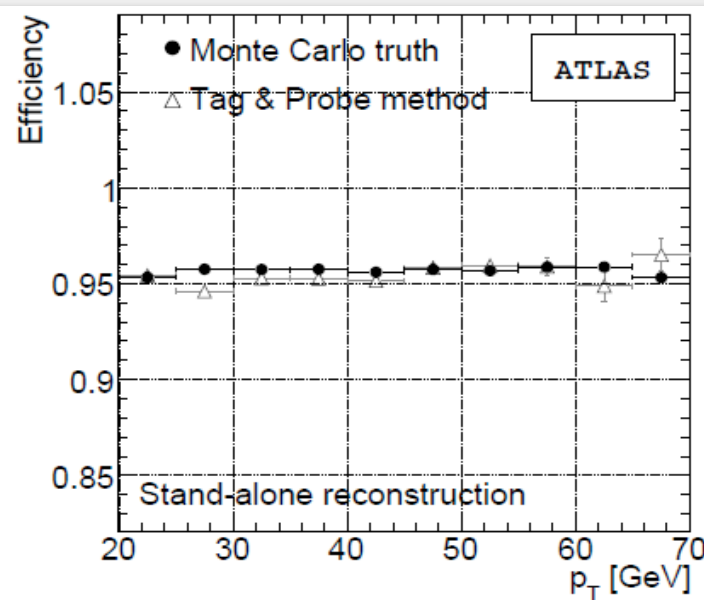
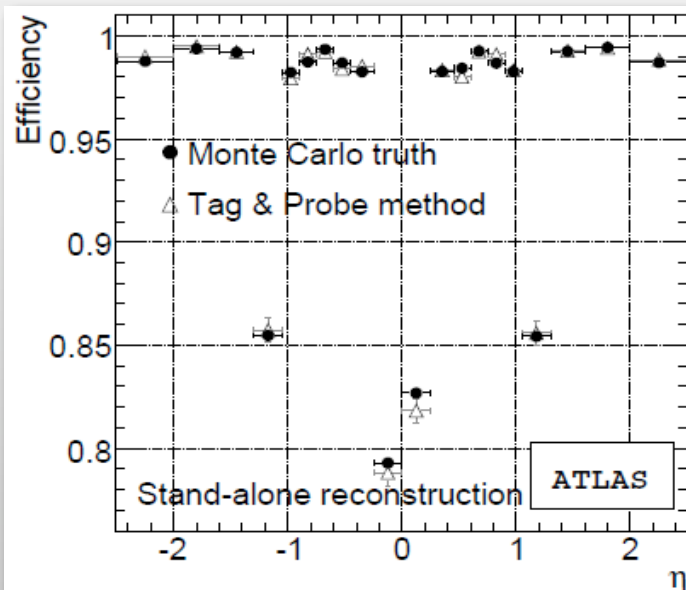


The Muon Spectrometer Performance with Z

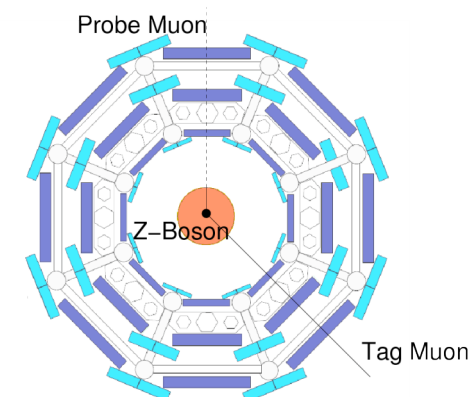
- $Z \rightarrow \mu\mu$ samples used to determine the Muon Spectrometer performances:

The TAG and PROBE method is used to measure the efficiency:

- use InnerDetector-MuonSpectrometer (ID-MS) combined tracks
- require two reconstructed tracks in the inner detector with invariant mass close to the mass of the Z
- at least one associated track in the muon spectrometer (the TAG muon)



TAG and PROBE method



Efficiency Measurement Accuracy:

- 100 pb^{-1} are required to achieve 1-2% *local efficiency* (300 bins in η , Φ , p_T)
- A statistical precision of 1% of the overall muon spectrometer reconstruction efficiency can be reached with less than 1 pb^{-1}

TOP QUARK physics at $\sim 100 \text{ pb}^{-1}$

LHC will be a **top factory**

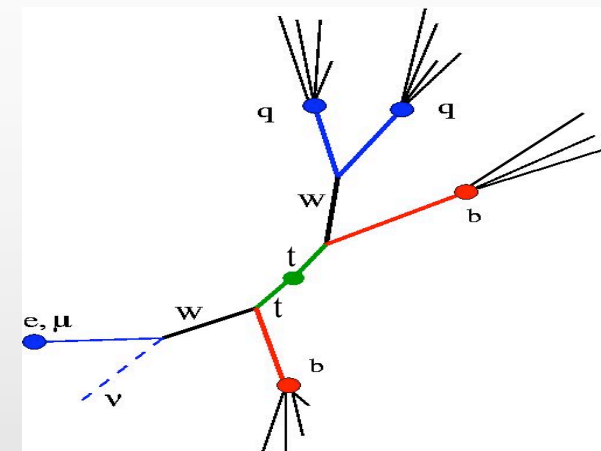
$\sigma_{tt} \sim 830 \text{ pb}$ @ 14 TeV ($\sim \times 100$ TeVatron)

$\text{BR}(t \rightarrow Wb) \sim 100\%$

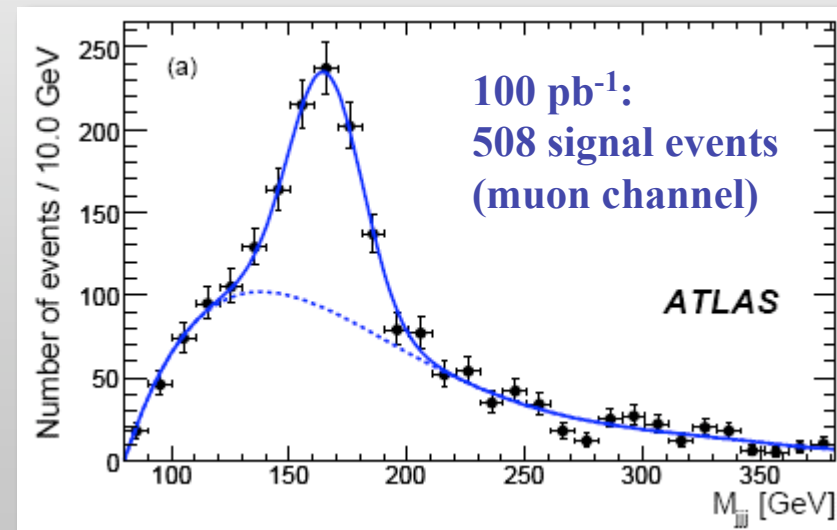
For the golden-channel lepton-jets:

$\sigma_{tt} \sim 250 \text{ pb}$ for $tt \rightarrow bW bW \rightarrow bl\nu bjj$

expect ~ 500 events in the muon channel (eff $\sim 4\%$) with **100 pb^{-1}**



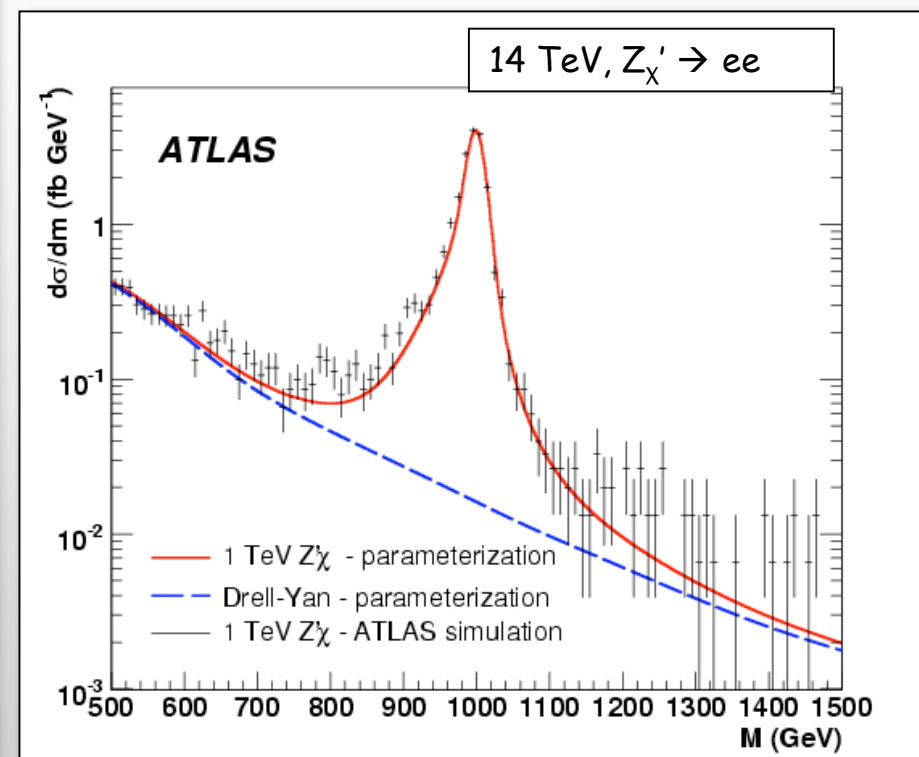
- Top signal observable in early days with no *b*-tagging and simple analysis
- Top quark events contain all relevant signatures: (e, μ , jet, E_{miss} , b-jet)
- **a milestone in physics commissioning**
- Excellent sample for e.g.
 - commission b-tagging,
 - set jet E-scale using $W \rightarrow jj$ peak



$$\Delta\sigma/\sigma = 7\% \text{ (stat)} \pm 15\% \text{ (syst)} \pm 3\% \text{ (pdf)} \pm 5\% \text{ (lumi)}$$

WHAT about EARLY DISCOVERIES?

- New heavy states forming a narrow resonance (a gauge boson Z') decaying into opposite sign dileptons are predicted in many extensions of the Standard Model (*grand unified theories, Technicolor, little Higgs models, and models including extra dimensions*)
- The signal is a narrow mass peak above small and smooth SM background
- Does not require ultimate EM calorimeter performance
- with 100 pb^{-1} large enough signal for discovery up to $m > 1 \text{ TeV}$
- Ultimate ATLAS reach (300 fb^{-1}) would be a mass of about 5 TeV



CONCLUSIONS

...just READY and eager TO START!

Delivered!



December 2009 ?

*December 2009 ?
- 2010 !!!*



BACKUP SLIDES

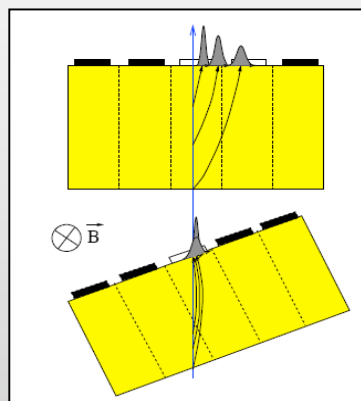
Pixel - measurement of Lorentz angle

The measurement of Lorentz angle is important for reaching ultimate precision

MC predictions at 2 Tesla: ~ 224 mrad

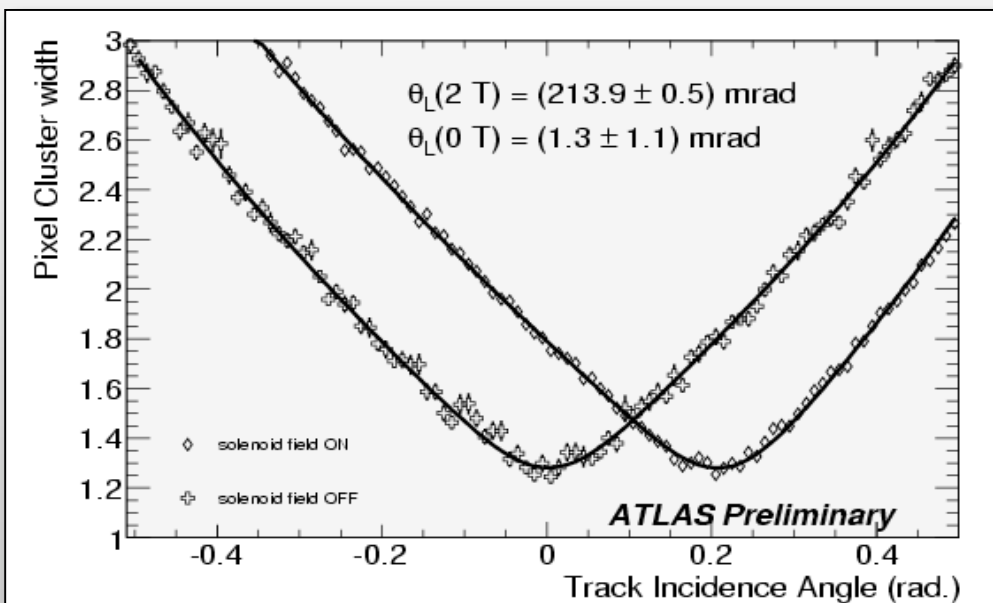
Results with cosmics data at 2 Tesla: (213.9 ± 0.5) mrad

- Drift in silicon is affected by $\mathbf{E} \times \mathbf{B}$ effect
- Charge is (de)focused along the Lorentz angle direction
- The measured cluster width is minimized for tracks along the Lorentz angle



$$\tan \alpha_L = \mu_H B$$

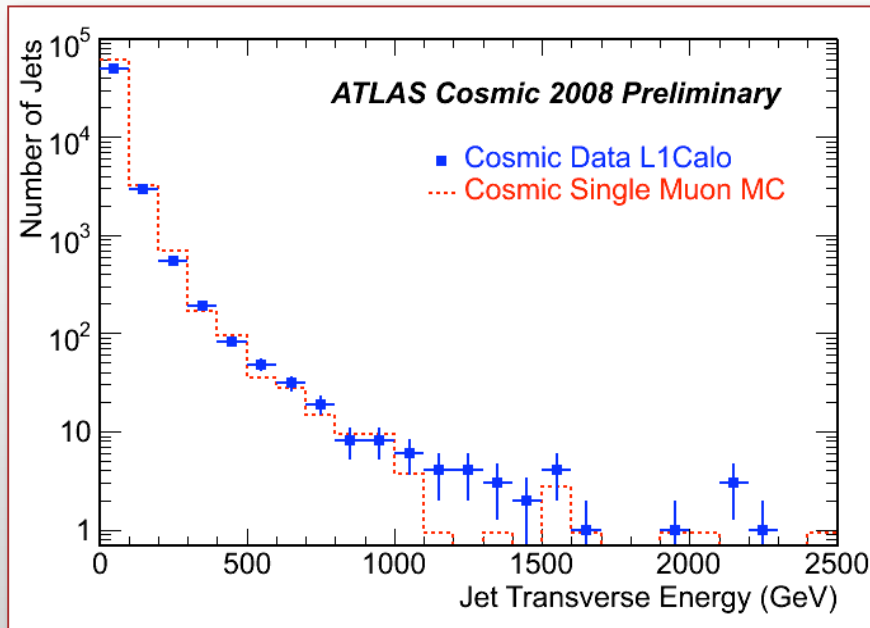
μ_H is the Hall mobility of charge carriers in silicon



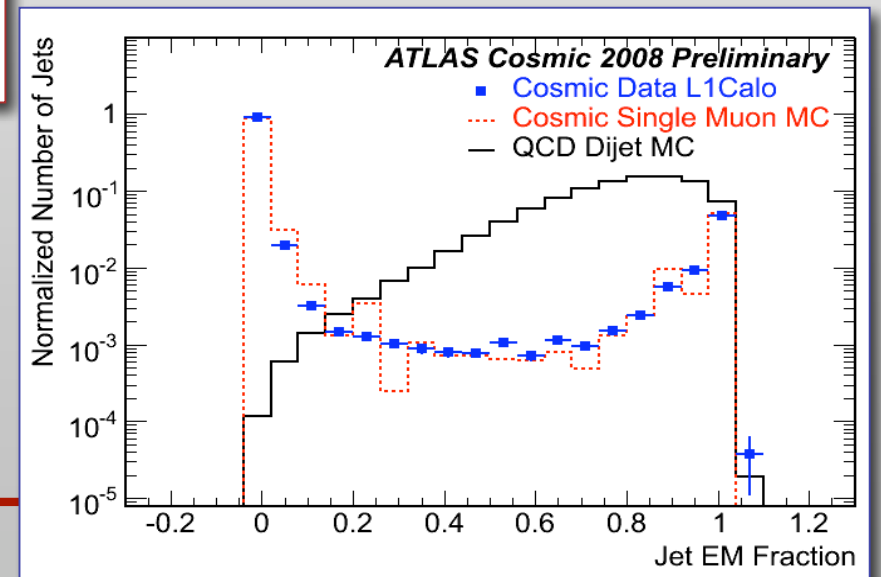
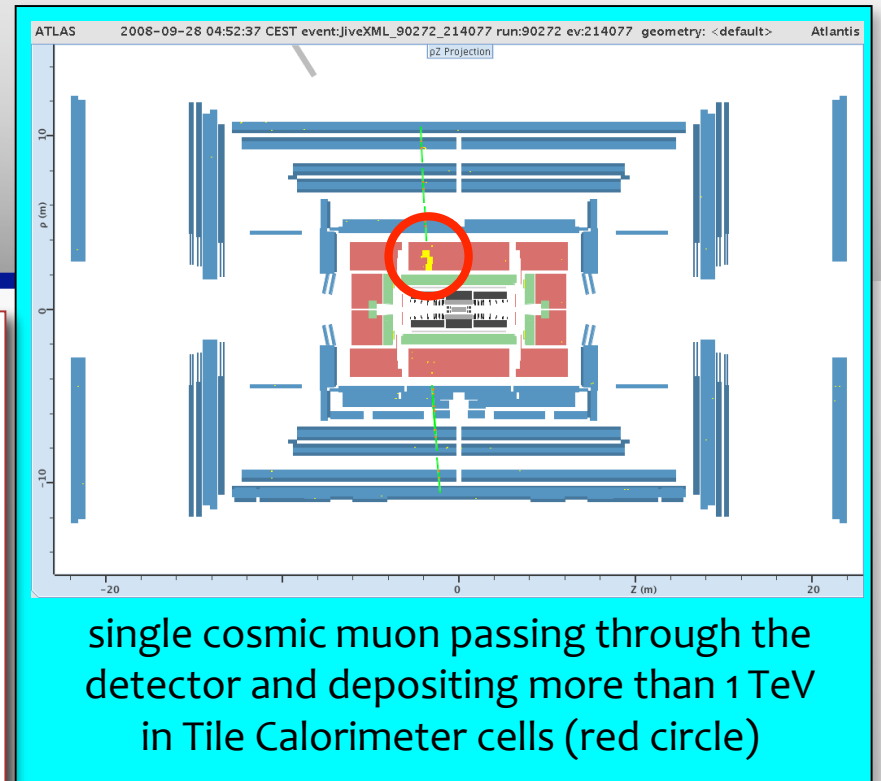
**Pixel Cluster Width
minimized at 2T for incident
tracks at (213.9 ± 0.5) mrad**

Jets results from highly energetic cosmic rays

Distribution of jet transverse energy from the cosmic data. The shape of the distribution is well described by the simulation

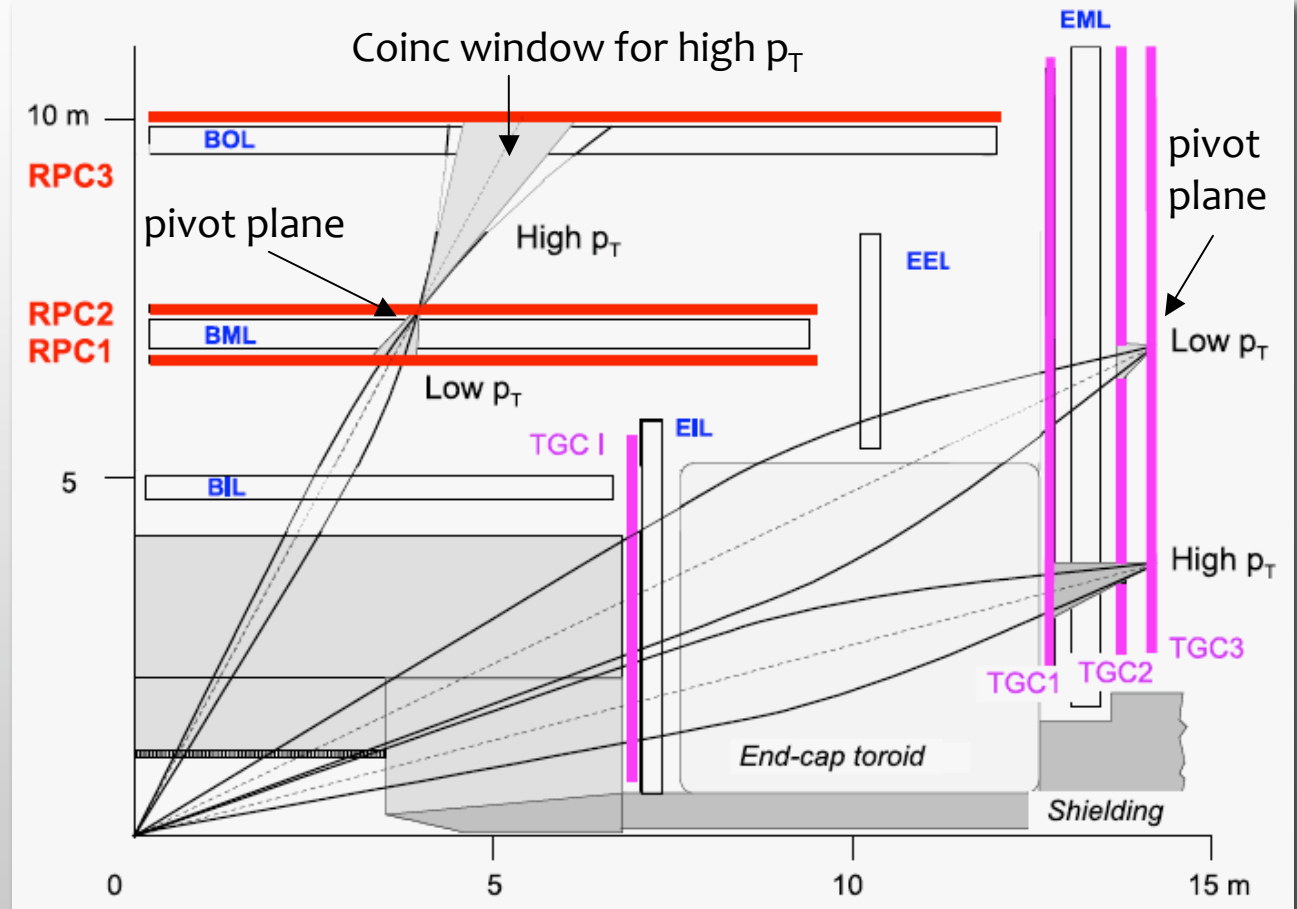


The jet EM fraction: ratio of the energy deposited in the EM calorimeter and the whole calorimeter. The most likely value for the EM fraction is 0 or 1 for fake jets from cosmic (high energy deposit from photons originated from high energetic muons will localize either in the EM or the hadronic calorimeter)
Good separation between real QCD jets and fake jets from cosmic is observed



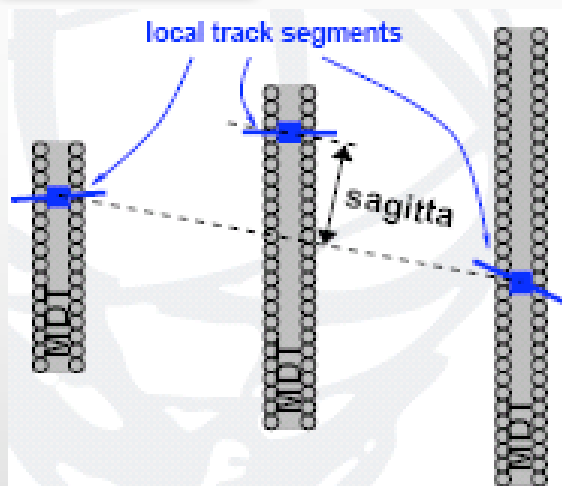
Three planes of trigger detectors both in barrel (RPC) and in endcap (TGC) background

- Interaction point and detector pivot plane define position of the coincidence window on the second and third detector planes
- Trigger selection performed both in the bending and in the non-bending planes to reduce fake trigger rates



- Multiple trigger thresholds :
Low p_T (6-10 Gev/c) and High p_T (11-40 Gev/c)

MDT Alignments in the Barrel (optical and w/ tracks)



- Barrel Optical Alignment: at 200 μm level for large sectors (0.5-1 mm for small sectors)

- Track based alignment: improvement to <50 μm level

Special run with Toroidal B-field off is needed.

To achieve 30 μm in both large and small sectors we need 100k pt>20GeV tracks per barrel sector. This will take ~ 5 days at $L=10^{31}$.

To achieve 30 μm in large sectors only (100 μm in small sectors) we need 100k pt>6GeV tracks per sector.

This requires 100 times less Luminosity/days

